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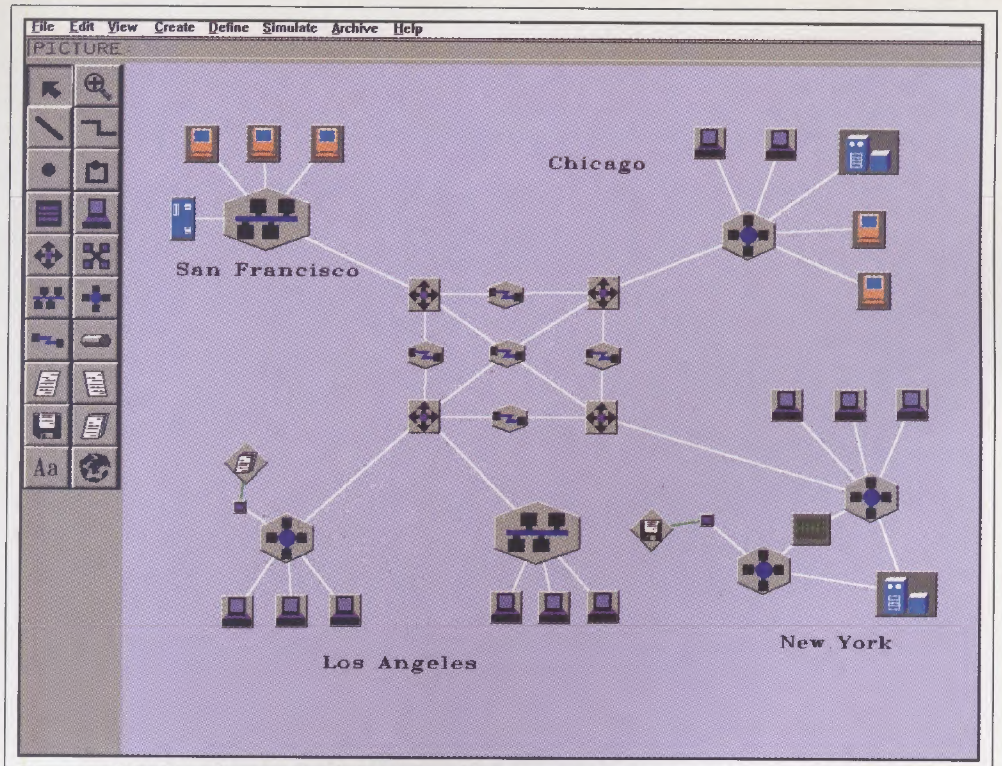

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Newslog

JUL 12. The French government gave the go-ahead to **Nersa**, a consortium of European energy companies, to restart the controversial Superphénix 1300-MW fast-breeder nuclear reactor, shut down in 1990 because of technical faults in its fuel-cooling systems. The plant, in Lyons, will now serve research into the burning of radioactive waste from France's 56 nuclear reactors. Nersa includes Eléctricité de France, Enel of Italy, and SBK of Germany.

JUL 12. Siemens AG, Munich, announced it would cut another 7000 jobs this year. The company said its workforce would be reduced to 385 000 by October.

JUL 14. U.S. **Secretary of Energy Hazel O'Leary** announced a series of agreements with **India** to establish long-term technical cooperation programs in power generation and sustainable energy development. Also announced were 11 energy ventures between U.S. and Indian companies, including a pact for low-cost photovoltaic technology between **Solec International Inc.**, Hawthorne, Calif., and India's **Pentafour Solec Technology** in Madras.

JUL 14. Nextel Communications Inc., Rutherford, N.J., said that it would pay US $650 million for **Onecomm Corp.**, Denver, Colo., which has wireless licenses in 23 states. On Aug. 5, Nextel agreed to buy **Dial Page Inc.**, an Atlanta, Ga., wireless operator, for $750 million, plus the U.S. wireless licenses owned by **Motorola Inc.**, Schaumburg, Ill., for $1.65 billion. The deals give Nextel licenses to serve 85 percent of the U.S. population.

JUL 15. Microsoft Corp., Redmond, Wash., said it had reached a settlement with the **U.S. Justice Department** to end a four-year antitrust battle. The settlement requires Microsoft to abandon several anticompetitive practices, including charging PC makers according to the number of computers they manufacture—whether or not the units are loaded with Microsoft's operating system. Microsoft said it had done nothing wrong and had settled the case to avoid continuing the long court battle.

JUL 19. Digital Equipment Corp., Maynard, Mass., said it had agreed to sell its disk storage business to **Quantum Corp.**, Milpitas, Calif., for $400 million. Included in the package are DEC's magnetic-disk drive, tape drive, solid-state disk, and thin-film heads businesses, plus its 81 percent interest in **Rocky Mountain Magnetics Inc.**, Louisville, Colo., which is developing magneto-resistive head technology.

JUL 20. U.S. **Vice President Al Gore** said the Administration was willing to explore alternatives to its **Clipper chip technology** to encrypt computer communications. Gore said the Clipper chip would still be used for telephone communications, but a five-month study would be conducted for a computer communications system that would be voluntary, not rely on a classified computer encryption formula, and be exportable—all key demands of industry.

JUL 20. The **House of Representatives' Science Committee** said it had voted to require the **National Aeronautics and Space Administration** to track all comets and asteroids greater than 1 km wide that cross earth's orbit. NASA began working on a six-month study for a telescope warning system. Scientists estimate that 2000 such intruders may be speeding through space and could damage the earth.

JUL 25. Airtouch Communications Inc., Walnut Creek, Calif., spun off recently by Pacific Telesis, and **U.S. West Inc.**, Englewood, Colo., said they would combine their domestic cellular telephone businesses, which operate in 21 states.

JUL 29. The **Federal Communications Commission** said it had raised $617 million for the Federal government from the sale of 10 radio-frequency licenses for nationwide advanced paging networks and had also taken in $216 million for 300 licenses for interactive television services. Two of the five largest national licenses, each comprising two 50-kHz channels and costing $80 million, went to **Paging Network Inc.**, another two to **KDM Messaging**, mainly owned by McCaw Cellular Communications, and one to **Nationwide Wireless Network**, formed by Mobile Telecommunications and Microsoft.

AUG 1. Macromedia Inc., San Francisco, and **Microwave Systems Corp.**, Des Moines, Iowa, announced the development of a new technology that will automate the conversion of PC programs to run on interactive TV networks. The companies said the technology would cut the time required to rewrite a multimedia program, like a restaurant guide, for interactive TV from a year to about a month—at a fraction of the $500 000 it now costs.

AUG 2. NASA said an eight-legged, 770-kg, 3-meter tall robot named **Dante II** had completed its exploration of the crater floor of Mount Spurr, an active volcano near Anchorage, Alaska. The robot, studded with sensors and eight video cameras, trekked 200 meters into the volcano, mapped its surface, and measured the heat and composition of escaping gases for seven days. Built by **Carnegie Mellon University** in Pittsburgh, Dante broke one of its legs while climbing out of the crater and toppled over. At press time, rescue efforts to retrieve the robot by helicopter were continuing.

AUG 3. Fujitsu Ltd. and **IBM Corp.** said they and several other leading electronics manufacturers—including Hitachi, Sony, Sharp, Hewlett-Packard, and Philips Electronics—had joined to promote standardization of magneto-optical discs capable of storing over 600 MB.

AUG 3. Time Warner Communications, Stamford, Conn., said it had hired **AT&T Network Systems**, Morristown, N.J., to equip its cable TV systems in 25 cities with telephone network gear. The first installation in the five-year, $200 million contract is to be in Rochester, N.Y., where Time Warner agreed in May to link its cable lines with **Rochester Telephone Corp.'s** network. The installation of phone equipment in cable systems outside New York State hinges on changes in state regulations.

AUG 4. The **Chinese government** said that it had seized 200 000 pirated compact discs in the first half of this year, as well as 750 000 video and audio tapes that violated copyright laws. Authorities, pressed by the United States for stronger protection of foreign intellectual property rights, declared the clampdown a success.

AUG 8. Cray Research Inc., Eagan, Minn., said that it had won an order for its C90 supercomputer from the government-funded **Tokyo Institute of Technology** in direct competition with a Japanese company. The sale represents a breakthrough following more than a decade of U.S. allegations that Japan had discriminated against U.S. manufacturers.

Preview:
SEP 26–28. The **Information Superhighway Summit** is to be held in San Jose, Calif., with speakers debating which course the national communications infrastructure will take. For more information, contact IDG World Expo Corp. at 800-545-3976 or McQuillan Consulting at 617-491-6754. [See related story, "Upgrading the information infrastructure," pp. 22–29.]

Sally Cahur

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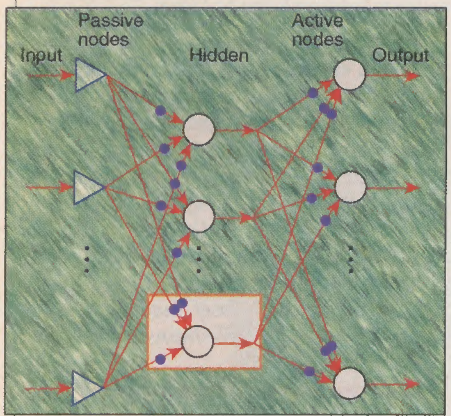
IEEE SPECTRUM

APPLICATIONS



47 Manufacturing ICs the neural way

By GARY S. MAY

Neural networks have recently emerged as a powerful aid in computer-integrated manufacturing of ICs. Such neural networks (above) help engineers infer subtle input-output relationships.

MANAGEMENT

52 Making electronic documents work

By COLIN MAUNDER

Electronic versions of documents can be more useful than their paper counterparts, but implementing an electronic system for documentation requires forethought and cooperation.

THE INSTITUTE

57 IEEE Awards for '94

Seven engineers are named for engineering leadership, services to the Institute, and best papers, and an organization is cited for innovation.

Cover: Fierce competition in the commercial marketplace is putting a lot of pressure on engineers and scientists in industrial research laboratories to do more with fewer resources, fewer people, and less time. See p. 30. Illustration by Brian Ahjar.

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Editorial Board

Forum

Judgment's subtle presence

I suppose some readers will be quite impressed by "Reengineering government processes" [January, p. 19]. The case is nicely presented and illustrated, but I have strong reservations about the scenario described, just as I did about the estimated million or so lines of code that were to have been a prominent part of our isolation from intercontinental ballistic missile attack. Even assuming that a million lines of code could be made to behave, there were bound to be many decisions imbedded, intentionally or not.

Rarely does any organization, governmental or industrial, completely specify all plausible sets of inputs to a large program, and perhaps more rarely does the program get adequately tested to that incomplete specification. It is entirely too easy to overlook or underestimate all possible states that arise in the manual systems to be replaced and all the myriad decisions that occur, with the result that some responses of the finished product are unplanned, even unsuspected. If a programmer finds him- or herself absent a specification during coding, it is simpler to "make a good assumption" than to see proper resolution, which slows the project and increases the cost.

I have seen innumerable instances where the commitment of what should be supervisory or middle-management (read human) decisions to software has resulted in improper actions and customer alienation. There are examples from power and telephone companies, from organizations charted by government, and more.

One of the author's scenarios is an obvious example of improper procurement actions that might plausibly occur if the system is incompletely or inadequately specified and verified; that is when the logistics manager reviews producer records and manufacturing data and inputs "accept and pay." I would rather opt for "accept and ship," and await proper receiving and perhaps some level of inspection before authorizing "pay," so as to ensure that the right product reached the right destination in an acceptable time. Proceeding as described can only be described as an act of faith by government.

I suppose it is possible that a procuring agency receive and monitor or review ongoing statistical process control data, but again this involves faith that there are no errors or gaps in such data.

With the enormous and still-expanding ability of computer systems, it is easy to become enamored of using them in complex processes, but just as manufacturing has found it hard to replace experts completely with expert systems, logistics and other functions will find it hard to replace the elusive element of judgment that subtly intrudes itself into virtually all complex intellectual activity.

Robert W. Reichard
South Natick, Mass.

Enlightenment on Indian matters

The excellent profile of Mathukumalli Vidyasagar [July, pp. 56–8] reflects well on the growing diversity of the IEEE membership. However, I would like to elaborate on a few points.

On the meaning of Vidyasagar's favorite quotation (*karmanyevaadhikaarasthe maa phaleshu kadaachana*): although the translation of the famous line from the *Bhagavad Gita* is correct in a literal sense, it is likely to be misinterpreted. Perhaps a more appropriate version is: focus on your action (*karma*) without worrying about its rewards. In other words, execute a task or project well (inventing a widget, say) because it is intrinsically satisfying and the right thing to do, and not because of extrinsic factors such as money and fame. A person who follows such a philosophy of life (even partially) will enjoy his work more, and avoid a lot of stress and disappointment. He may also lead a happier and healthier life in spite of a smaller investment portfolio.

On an "arranged" or "introduced" marriage: I think such a marriage can be more aptly described as "consensual" because the decision involves the participation and consent of many people besides the would-be couple and their parents. From this cultural perspective, a Western marriage, where an individual takes the initiative in selecting his or her future spouse (through a trial-and-error courtship) can be considered an "individually arranged" or "self-arranged" marriage.

Finally, readers may wonder why Vidyasagar's relatives have the same first name. That is because in many parts of India, the family name (Mathukumalli) comes first and the given name (Vidyasagar) last.

Vijay Gupta
Cupertino, Calif.

What really worked at NASA

The article "L + 25: A quarter century after the Apollo landing" [July, pp. 16–29] was not only informative and entertaining but also made it quite clear that the key to NASA's success in this period was the individuals involved and their personal desire to see the project successfully completed. The management structure at NASA, which has not changed much over its history, really could not compensate for the loss of those individuals when they retired or quit, as the recent spate of disasters (Challenger, Hubble, and others) has shown.

This is a valuable lesson for everyone involved in engineering, R&D, and manufacturing. Today, so much focus is put on fancy management strategies, and so many millions are wasted on management consulting, when the key to success is getting people to care about what they are doing. This happened almost automatically in the early years of NASA because for the people involved, it was more than a job, it was a quest.

Josef Shaoul
Westminster West, Vt.

LEDs light the way out

The article "Higher visibility for LEDs" [July, pp. 30–34 and p. 39] missed one of the largest uses today of light-emitting diodes (LEDs). Our company, Astralite, in Annandale, N.J., working in conjunction with the Environmental Protection Agency's Green Lights Ally program and various power utilities, has developed and marketed an LED retrofit for incandescent lamps used in the over 100 million exit signs that exist in every public and commercial building. Through the use of vertical strips, embedded with 3000-mcd red LEDs, power consumption by these signs, which must stay on 24 hours a day, is reduced from 40 W to less than 2 W.

From an energy cost standpoint alone, the payback period averages less than one year. From a national standpoint, the impact of reducing energy demand in this one application is over 33 billion watt-hours per year. In this application, unlimited life is secondary to energy consumption.

Les Listwa
Annandale, N.J.

Navigating by GPS

Ivan Getting's thoughtful précis of the development of radio navigation systems and the Global Positioning System (GPS) in particular [December 1993, pp. 36–47] was very illuminating for research teams (including our own) that have been developing applications using GPS inputs. I have two quibbles, however.

Firstly, those of us living on this side of the Atlantic are also familiar with Decca Navigator, which is generally configured around a master and three slaves. The anecdotes I have heard imply that the U.S.

Forum

(Continued from p. 4)

military rejected its navigational potential just prior to World War II, leading its two designers to seek funding in the United Kingdom—hence the Decca link. It was used by the British forces during the latter part of the war. Unsurprisingly, the GPS is replacing Decca Navigator as a navigational tool (Racal-Decca supplies a front end that converts GPS into Navigator coordinate formats for the diehards).

Secondly, perhaps a brief review of some of the operational problems with GPS as a land navigation tool might have been given. In areas with tall buildings, GPS is blind and needs augmenting with, for example, passive infrared roadside beacons to keep track of vehicle location. This is the technological downside for those trying to develop anti-theft systems and other applications. Predictive techniques of determining where lies the "unseen" vehicle and where it may emerge are not totally reliable, even when accompanied by dead reckoning. New heterogeneous data capture and transport telematics architectures are required to utilize GPS fully on land.

The contribution of GPS to maritime navigation and safety is a proud and noble testament to Ivan Getting and all involved in the project. With due pun intended, let us hope to "land" their achievements over the next few years.

John G. Harpur
Maynooth, County Kildare
Ireland

Faraday on the money

Richard H. Engelmann's letter [May, p. 6] makes a good point about the way some countries honor their famous citizens by portraying them on banknotes. Unfortunately, he omits the note that is probably the most interesting to EEs—the Bank of England Series E £20 note introduced in 1991.

This note, developed with the latest anti-forgery technology, is a tribute to Michael Faraday and includes many details of his work. As well as his portrait, there is an illustration of him giving a Royal Institution Christmas lecture. The backdrop of the note features several patterns; one is a hexagonal pattern representing benzene (which Faraday separated from oil-gas in 1825), and another is made up of bar magnets joined by iron filings. Under a magnifying glass, a list of some scientific terms introduced by Faraday (electrode, ion, electrolysis, and others) can be seen. Other features include part of the Royal Institution's coat of arms and a circular droplet pattern representing Faraday's work on the liquefaction of gases.

Thus, a portrait of one of Britain's great EEs and a tribute to his work is in everyday use in the United Kingdom. Sadly, this seems to have made little impact on the image and status of British engineers, and there is still little recognition of the part played by EEs in wealth creation in the United Kingdom.

More information on the note and the technology used to develop it can be found in Dick Jones's "Making Money" (*IEE Review*, Institution of Electrical Engineers, June 1991, UK).

Simon R. Burne
The Hague, the Netherlands

Problematic problems

In the profile of Marcian E. (Ted) Hoff Jr. [February, pp. 46–49], the quotation "People who don't question the assumptions made going into a problem often end up solving the wrong problem" outlines one of the darkest and deadliest secrets of the information age. Even without the "information highway," the popular media bombard the public with the results of studies of problems in practically every discipline, but the assumptions on which the studies are based are rarely if ever stated. As a consequence, people are overloaded with doubtful information about problems that may or may not exist.

Milton E. Ballard
Tucson, Ariz.

The promise of contained fusion

On the subject of energy from nuclear fusion [February, pp. 31–36], readers should be aware that fusion power technology was perfected over 10 years ago. Contained fusion, not controlled fusion, is a proven method. Refer to "Practical Fusion Power" by Hammond, Hubbard, and Dooley in *Mechanical Engineering*, July 1982.

A much smaller, and therefore easier to implement, version of the scheme employing a technology called "ballotechnics" is discussed by Sam T. Cohen in *National Review*, Dec. 27, 1993. If ballotechnics turns out to be technically feasible, we could have a series of fusion reactors going in a couple of years.

Project Pacer, our contained fusion program, was canceled for political reasons.

Albert K. Heitzmann
Phoenix, Ariz.

Readers are invited to comment in this department on material previously published in *IEEE Spectrum*, on the policies and operations of the IEEE, and on technical, economic, or social matters of interest to the electrical and electronics engineering profession. Short, concise letters are preferred. The Editor reserves the right to limit debate on controversial issues. Contact: Forum, *IEEE Spectrum*, 345 E. 47th St., New York, NY 10017, U.S.A.; fax, 212-705-7453. The e-mail (Internet) address is n.hantman@ieee.org. For more information, call 212-705-7305 and ask for the Author's Guide.

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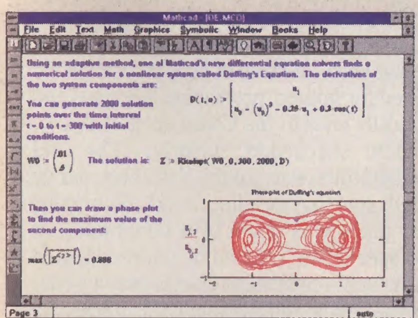

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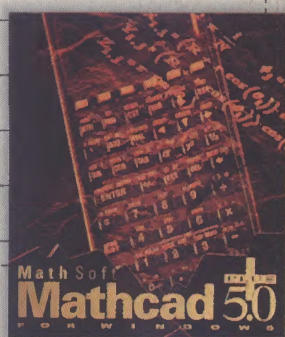

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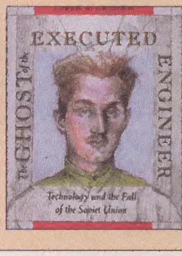
Books

Death of an engineer

Alexander V. Kalinin

The Ghost of the Executed Engineer: Technology and the Fall of the Soviet Union.
Graham, Loren R., Harvard University Press, Cambridge, Mass., 1993, 128 pp., $22.95.



In the spring of 1929, during one of Stalin's Great Purges of the Soviet Union, Peter Palchinsky, a 55-year-old industrial engineer and a former official in the short-lived provisional Government between the Tsarist and Bolshevik regimes, was executed by firing squad. Alone among eight engineers accused of conspiracy and treason in what became known as the Industrial Party Trial, he apparently refused to confess to a litany of trumped-up charges, and paid for his refusal with his life. The trial began a reign of terror in which several thousand Soviet engineers were arrested, out of a total of perhaps 10 000 in the entire USSR.

Using documents sequestered for years in Soviet archives, Loren R. Graham, a professor of the history of science at the Massachusetts Institute of Technology, has pieced together the fascinating story of this man and his role in a sad and little-known but momentous chapter in Soviet history. The biography becomes a parable of the subsequent decades of misuse and waste of technological talent, and helps explain why the USSR failed, in the author's words, "to become a modern industrialized country."

The book is about the society in which I was born, became a professor, and lived for 50 years. I finished reading it with mixed feelings. It is an outstanding book; the author has understood more clearly than I ever did why, at the moment of truth, so miserably few came to the defense of the former Soviet Union. Still, there were sections that could have benefited from other perspectives or deeper analysis. Graham's sympathy with Palchinsky is so intense that in some cases he attached altogether too much importance to him personally.

One of the issues that deserved deeper analysis is the relationship between bolshevism and technocratism. The latter, which proposes that engineers and technocrats direct a society's development as they would a factory, plant, military detachment, or (in the last version) a space ship, was actually borrowed by Russian socialists from Western ideas. In this respect, Stalin, the Bolshevik, and Palchinsky, a Socialist Revolutionary, had much in common. Both trusted in state monopoly, central planning, and industrialization and electrification as the cornerstones of social and economic policy.

Technocratism still survives in the Russian consciousness. Today's adherents try to explain even its failure in technocratic terms: they believe that if nascent efforts in computer science had not been suppressed for ideological reasons in the late 1940s and early 1950s, and, furthermore, had led to a supercomputer to plan for and distribute millions of goods and services throughout the economy, the Bolshevik model of socialism could have made a much stronger showing than it did against market capitalism.

These notions strike me as wistful thinking. Whether or not Prompartia, the possibly mythical party that Palchinsky supposedly led, actually plotted to take over the USSR, the group could never have ruled the USSR, shaken as it was by the 1917 Revolution and the Civil War. Nor could the group have succeeded even in a more civilized country.

The reason is not that the time for their "socialism with a human face" had not yet come. It is not that their approach to human and ecological factors as mere calculable externalities was too cynical. It was not that they failed to foresee powerful future tools like computers. The reason, simply, was their tragic failure to grasp the irrational nature of political power and the indeterminism of social history.

Consider the Dnieper River hydroelectric power plant, whose construction was a cornerstone of the USSR's first five-year plan, begun in 1927. To Palchinsky, the engineer and consistent technocrat, it was a symbol of economic ineffectiveness and ecological barbarism. To Stalin, the seminarist and politician-technocrat, it was a symbol of victory, solidarity, and glory.

Stalin knew profoundly the power of myths, symbols, and fears, and millions were induced to submit to his vision and leadership by terror, propaganda, and organization. For this, the rationalism of Palchinsky and his circle of intellectuals was no match: their beliefs were cool, logical, and short on emotional appeal. They lacked the instruments to rule the country.

Bolshevism failed not for lack of technocratism; on the contrary, it contained an essential ingredient of technocratism in its core. Moreover, the failure of bolshevism revealed technocratism's fangs: it turned out that technocratic ideology combined with "no limits" politics was a formula for totalitarian violence.

The failure of technocratism in turn was caused by its own fundamental, ideological flaws, rather than some quirks of Soviet society. True, the USSR rushed technocratic concepts of social improvement into practice "ahead of the entire planet," according to a 1970s' song by a prominent dissident. It is also true that the Soviet Union was prone to push borrowed ideas to extremes, sometimes grotesquely so. To a degree, however, such crimes have since been expiated by the bitter costs paid and by the value of their warning to mankind.

Another area where Graham's analysis could have been deeper is in the discussion of education in Soviet society. He rightly criticized the Soviet system of engineering education, which produced exceedingly narrow individuals. Ultimately, there were unhappy political consequences, when many of these people, with their simplistic social and political vision, wound up in high Government office—Leonid Brezhnev and Nicolai Kosygin, a prime minister in the 1970s, were products of the engineering educational system, as was Kosygin's successor, Vladimir Tikhonov. A solid majority of the Politburo, too, had engineering backgrounds.

Graham's analysis of this issue could have benefited from other perspectives. Bolshevik education was in part a reaction to the liberal pre-revolutionary education provided to a privileged minority. This educational system had many fine points, but it also created a social stratum that never had clear parallels in bourgeois Europe: intelligent people who were almost literally good for nothing, over-educated and under-involved. (Indeed, the word *intelligentsia* came from Russia.)

The intelligentsia was the traditional wellspring of public dissent, starting with so-called "extra people": well-educated people whose disconnection from society, and inability to contribute to it, led them to various forms of protest—up to and including political terrorism. Recognizing this, the Bolsheviks sought to form a new, "red" intelligentsia, an army of people vocationally trained for limited, productive functions and politically loyal to the Communist Party.

They succeeded, utterly. The old intelligentsia was partly absorbed, partly exiled, and partly eliminated. Gradually, their place was taken by a community of "red specialists" created by unprecedented efforts and a consistent discriminatory educational policy: education in natural sciences and engineering was split off from the study of the political and social sciences. Social origin and political loyalty were valued far above school grades and talents. Children of the former privileged classes, for example, were disadvantaged.

The social landscape 10 years later was akin

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Circle No. 2

to a battlefield, promising catastrophe in the long run. On one side were the Party soldiers, social scientists, and propagandists, educated only in Marxism-Leninism. On the other side was an army of highly qualified engineers, physicists, and chemists, with only the foggiest notions of ethics, psychology, and economics.

Graham is much taken by a chance meeting he had with a graduate of a Soviet engineering institution, a young woman who seemed proud of her degree in "ball-bearings for paper mills." The anecdote is a vivid one, but Graham seems to have been so impressed by the incident that it colored his whole view of Soviet education. I myself never encountered academic specialization quite this extreme. In any event, let's face it: narrow but thorough preparation is often a better ticket in the job market than a broadly humanistic education, in the United States as well as in Russia.

In the 1930s and 1940s, moreover, narrow specialization bore fruit. The engineers and scientists so trained became the backbone of the emerging Soviet military-industrial complex. Solzhenitsin called them *obrazovanschina,* a quasi-educated community with narrow views and low moral standards.

Don't be deceived by this humiliating term. There were thousands of intelligent individuals and brilliant specialists among the *obrazovanschina.* Otherwise, how could the attack of Nazi Germany have been endured? They managed to create the world's second-largest (though military-oriented) economy, developed key modern technologies, and demonstrated world-class accomplishments in fundamental sciences—all in an essentially poor country tortured by wars and terror.

In fact, by the 1960s, the Soviet Union had developed the largest corps of engineers and applied scientists the world had yet seen. The low efficiency of Soviet labor and the declining level of normal education was somewhat offset by a steady, massive inflow of the USSR's best intellectual resources. Physics and engineering ranked highest among Soviet youth, and an engineering career was an honorable preliminary for aspiring Government officials, just as military service had been for the sons of the former Russian nobility.

I myself, having graduated from Moscow's Power Engineering Institute and Lomonosov State University, and having taught at three Moscow technical institutes and two U.S. institutions, can testify that the level of basic education in fundamental sciences and engineering in Soviet higher education often exceeded its U.S. counterpart. (I hasten to add that this only relates to the best Soviet schools.) It is no coincidence that by some rough and unofficial estimates by friends and colleagues of mine, 20 percent of U.S. software products were developed from principles worked out by applied mathematicians from the former USSR.

Nonetheless, the USSR began falling behind in scientific and engineering education in the 1970s, when U.S. universities began embracing computers and computer science, and when the quality of the Soviet professorship deteriorated and financing was cut.

As for the Soviet regime itself, it fell victim to two deadly diseases, both caught from the educational system. First, the recruitment of members of the ruling elite degenerated, basically, into choosing managers from the waste heap of the engineering community. Second, the Soviet science and engineering elite lacked not only humanitarian education, but social responsibility as well.

Overproduction of engineers, little professional freedom, and low salaries led to massive dissatisfaction. Beginning in the 1970s, engineers working as bus drivers, plumbers, or accountants scarcely raised an eyebrow. Almost any career could start with an engineering diploma. In the Soviet Union, many engineers pursued politics, where selection and advancement was based on loyalty

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...e Machine: The Emerging ...ial Life. *Emmeche, Claus,* ...sity Press, Princeton, N.J., ...95.

...kiest Questions: 402 ...will stump, amuse, and ... ...*r, Paul,* Owl Book/Henry ...1994, 285 pp., $10.95.

The High Performance Fortran Handbook. *Koebel, Charles H., et al.,* MIT Press, Cambridge, Mass., 1994, 300 pp., $45 (cloth), $24.95 (paperback).

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executive director of the International Moscow Energy Club, and was a senior research scientist in the USSR's Academy of Sciences.

EDITOR: Glenn Zorpette

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Books

to and membership in the Communist Party.

As Graham points out, the Soviet regime became a government of engineers, but what he overlooks is that most were failed engineers. After all, they were willing to abandon engineering in their twenties or thirties to become party functionaries. Meanwhile, in industry and academia, management and faculties were gradually becoming dominated by individuals with the strongest Party connections and least professional merit. In other words, the least deserving were reaping the greatest rewards.

In tracing the roots of the Soviet Union's demise, Graham may have placed too much blame on the narrowness of engineering education. A narrowly educated technical elite was a problem, but it would be inaccurate to single out educational deficiencies as the cause of the pervasive social irresponsibility. And it was sheer recklessness on the part of the political and engineering leaders that fed the most aggressive and often disastrous projects of the 1930s–1970s, including the fateful construction of the cellulose plant at Lake Baikal. Conscienceless politicians directed conscienceless engineers and scientists, and conscienceless scientists served conscienceless politicians. The loss of morality was becoming ubiquitous.

Even the better specialists appeared deaf to the arguments of environmental ethics and human safety. The drama of Baikal awakened the society, the tragedy of Chernobyl laid bare the source of danger: an immoral alliance of political and engineering elites.

The building cracked from the top down, and the Soviet system could not withstand the crisis. The result is well-known. The executed engineer has been vindicated.

The Cold War is over. However, the story of the greatest challenge to the United States at its zenith of political and economic power by a fundamentally flawed system that was, nonetheless, far from a paper tiger, deserves more attention than it is generally paid today. Graham's compelling and well-researched book contributes greatly to this cause.

Alexander V. Kalinin is professor of science and technology management at the Monterey Institute for International Studies in California. He was previously one of five main faculty members in the Department of Natural Resources at the Academy of National Economy, under the Soviet Union's Council of Ministers. He had also served as deputy executive director of the International Moscow Energy Club, and was a senior research scientist in the USSR's Academy of Sciences.

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Recent books

Solid State Physics, Vol. 48. Eds. *Ehrenreich, Henry,* and *Spaepen, Frans,* Academic Press, New York, 1994, 434 pp., $49.

Digital Simulation of Dynamic Systems: A Control Theory Approach. *Hartley, Tom T., et al.,* Prentice Hall, Englewood Cliffs, N.J., 1994, 393 pp., $58.

Chua's Circuit: A Paradigm for CHAOS. Ed. *Madan, Rabinder N.,* World Scientific Publishing, River Edge, N.J., 1993, 1043 pp., $168.

The Garden in the Machine: The Emerging Science of Artificial Life. *Emmeche, Claus,* Princeton University Press, Princeton, N.J., 1994, 199 pp., $24.95.

Science's Trickiest Questions: 402 questions that will stump, amuse, and surprise. *Kuttner, Paul,* Owl Book/Henry Holt, New York, 1994, 285 pp., $10.95.

The High Performance Fortran Handbook. *Koebel, Charles H., et al.,* MIT Press, Cambridge, Mass., 1994, 300 pp., $45 (cloth), $24.95 (paperback).

EV watch

EPA acknowledges flaws in anti-EV report

Because of overwhelmingly negative criticism, the Environmental Protection Agency (EPA) is likely to trash, if it hasn't already, its assessment of electric vehicle (EV) efficiency and overall impact of EVs on air quality. In its so-called Preliminary Electric Vehicle Assessment last November, the agency concluded that EVs would fail to achieve zero emissions because the electric utilities that would charge EV batteries emit as many harmful pollutants as the internal combustion vehicles that EVs would replace. Critics, such as the Edison Electric Institute, the Electric Power Research Institute, and the Electric Transport Coalition, charged that the EPA had relied on inefficient simulations of electric vehicle performance that did not take into account the latest EV technology and used old electric utility emissions data.

The EPA actually began backing away from its assessment almost immediately. Last March it qualified the assessment as a "work-in-progress." The Agency admitted that the report had not been peer reviewed, relied on oversimplified assumptions, and should not have been released to the public. More recently, the EPA has been organizing a workshop that will consider the best methods for determining the life-cycle emissions of an EV infrastructure. First scheduled for June, then postponed to September, the workshop may take place sometime in the fall.

Hybrids take center stage in Motown

It is surely no coincidence that June's Hybrid Electric Vehicle Challenge took place at Lawrence Technological University in Southfield, Mich., in the heartland of the U. S. automobile industry. Given the lack of a really promising EV battery technology, and given, too, the commitment to zero-emission vehicles demonstrated by regional air-quality control agencies, hybrids seem increasingly the way to go.

Hybrid electric vehicles can operate in a zero-emissions mode, but do not suffer the range limitations automakers fear would make pure EVs hard to sell. As one of the judges at the Challenge, Balarama V. Murty from General Motors Research and Development Center in Warren, Mich., put it, "a hybrid vehicle's environmental impact is potentially like an electric vehicle's without the disadvantages." Hence the growing interest in them in the Greater Detroit area.

The Hybrid Electric Vehicle Challenge, a student engineering competition, had several events, of which the most noteworthy were those for range and acceleration. The 40 vehicles entered in the Challenge were of three types: 16 of them were converted Ford Escorts, 12 were designed expressly as hybrid vehicles, and 12 were converted Saturn models.

The Response II was built by students at Lawrence Technological University expressly as a hybrid vehicle. Lawrence hosted the second annual hybrid vehicle competition with support from such organizations as the Society of Automotive Engineers and Saturn Corp.

The Escorts and purpose-built cars were series-type designs—basically EVs with a range-extending heat engine, which takes over when the battery runs out of charge. The Saturn conversions, on the other hand, were power-assist, or parallel, designs, with the heat engine and the electric motor able to power the drive shaft together.

Keith Wipke, from the Department of Energy's National Renewable Energy Laboratory in Golden, Colo., collected and analyzed data on a number of events in the race, to determine the effects of different hybrid control strategies on energy effectiveness and driving performance. During the range test, for example, the range-extender vehicles were found to be 45.8 percent more effective than the power-assist type. In the acceleration test, the hybrid's peak power was found to be within 10–15 percent of the manufacturer's ratings for most vehicles. Furthermore, charging efficiency increased 39 percent over 1993 average efficiencies.

Although hybrid EVs do indeed have fuel-burning heat engines, they are nowhere nearly as polluting as conventional vehicles even when their heat engines are operating. There are two reasons. First, the heat engines can be quite small since the vehicles rely on their electric motors for acceleration and climbing hills. Second, their engines operate at a fixed or slowly changing speed, which makes it easy to keep emissions under tight control.

Solar Splash in a lake

About 200 college engineering students from Japan, Puerto Rico, and the United States were scheduled to race this August in a regatta where only sunlight could serve as a source of electricity for driving the DC motors and propellers driving the boats. The Solar Splash regatta's venue was a lake about 30 km west of Milwaukee, Wis.

Designs had to use solar photovoltaic panels to recharge two on-board Johnson Controls 12-V lead-acid batteries. These were the boats' main power sources for motors rated between 0.4 and 2 kW in the speed and endurance races.

The regatta's co-sponsors were Johnson Controls, a Milwaukee-based manufacturer of automotive replacement batteries, and the solar energy division of the American Society of Mechanical Engineers, New York City. Each boat had to undergo rigorous safety and technical tests, and the IEEE was to provide technical assistance with the judging and competition.

EV news on the Internet

Calsol, the solar vehicle race team from the University of California at Berkeley, is also a presence on World Wide Web. It has most recently "published" updates of its activities on solar car design in the Calsol Page, the address of which is http://www-lips.ece.utexas.edu/~delayman/calsol.html.

The page is still under construction, but so far it provides the address, phone number, and e-mail for Calsol, as well as articles on past and future solar vehicle races. Thus, clicking on "Sunrayce '95" will bring up an article stating that the race will start on June 28, 1995, at the Indianapolis Motor Speedway, and end in Golden, Colo., at the National Renewable Energy Laboratory.

EDITOR: Michael J. Riezenman, with reporting by Maya A. Kaplan and Victoria J. Moore
CONSULTANT: Victor Wouk, Victor Wouk Associates

Calendar

SEPTEMBER

International Conference on Intelligent Robots and Systems—IROS '94 (IE, RA); Sept. 12–16; Universität der Bundeswehr München, Neubiberg, Germany; Volker Graefe, UniBwM, 8014 Neubiberg, Germany; (49+89) 6004 3590/3587; fax, (49+89) 6004 3074.

Oceans '94 (OE); Sept. 13–16; Parc Penfeld, Brest, France; Ginette Bonami, SEE, 48 rue de la Procession, F-75724 Paris, Cedex 15, France; (33+1) 4449 6060; fax, (33+1) 4449 6044.

Seventh European Signal Processing Conference—Eusipco '94 (SP); Sept. 13–16; University of Edinburgh, Scotland; Colin F.N. Cowan, Eusipco '94 Secretariat, Department of Electronic and Electrical Engineering, University of Technology, Loughborough, Leics., LE11 3TU, Britain; (44+509) 223 468; fax, (44+508) 222 830.

International Broadcasting Convention—IBC '94 (BT, Region 8, et al.); Sept. 16–20; RAI Congress Centre, Amsterdam, the Netherlands; IBC Secretariat, c/o IEE, Savoy Place, London WC2R OBL, England; (44+71) 240 3839; fax, (44+71) 497 3633.

International Symposium on Compound Semiconductors (ED, LEO); Sept. 18–22; Del Coronado Hotel, San Diego, Calif.; James Harbison, Bellcore, 331 Newman Springs Rd., Room 3X-211, Red Bank, NJ 07701; 908-758-3386; fax, 908-758-4372.

International Symposium on Ultra Clean Processing of Silicon Surfaces (ED); Sept. 19–21; Johns Hospital, Bruges, Belgium; Marc Heyns, IMEC, Kapeldreff 75, B-3001 Leuven, Belgium; (32+16) 28 12 48; fax, (32+16) 28 12 14.

Application Specific Integrated Circuits Conference and Exhibit (C, Rochester Section); Sept. 19–23; Rochester Riverside Convention Center, New York; Lynne M. Engelbrecht, Rochester Engineering Society, 1806 Lyell Ave., Rochester, NY 14606; 716-254-2350; fax, 716-254-2237.

14th International Semiconductor Laser Conference (LEO); Sept. 19–23; Hyatt Regency Maui, Hawaii; S. H. Phillips, IEEE/LEOS, 445 Hoes Lane, Box 1331, Piscataway, NJ 08855-1331; 908-562-3894; fax, 908-562-1571; e-mail, s.phillips@ieee.org.

International Conference on Software Maintenance (C); Sept. 19–23; Empress Hotel, Victoria, BC, Canada; Lee J. White, Case Western Reserve University, Department CES, 511 Crawford Hall, Cleveland, OH 44106; 216-368-2802; fax, 216-368-28011 e-mail, leew@alpha.ces.cwru.edu.

Autotestcon '94 (AES, IM, et al.); Sept. 20–22; Disneyland Hotel, Anaheim, Calif.; Robert Rassa, ManTech International, 150 S. Los Robles Ave., Suite 350, Pasadena, CA 91101; 818-577-7100; fax, 818-577-7102.

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(Continued from p. 16)

International Conference on Harmonics in Power Systems—ICHPS VI (PE); Sept. 21–23; University of Bologna, Italy; Gian Carlo Montanari, Instituto de Elettrotecnia Industriale, University of Bologna, Viale Risorgimento 2, 40136 Bologna, Italy; (39+51) 644 3471; fax, (39+51) 644 3470.

Professional Development Seminar—An Overview of Multimedia Technologies and Services (N.J. Coast Section, Computer Chapter); Sept. 22; Ocean Place Hilton, Long Branch, N.J.; Bala S. Prasanna, Room 1A-310, AT&T Bell Labs, 480 Redhill Rd., NJ 07748; 908-615-4486; fax, 4637; e-mail, joypras@corona.att.com.

44th Broadcast Symposium (BT); Sept. 22–23; Hotel Washington, District of Columbia; Edmund A. Williams, Public Broadcasting Service, 1320 Braddock Place, Alexandria, VA 22314; 703-739-5172; fax, 703-739-8938.

Canadian Conference on Electrical and Computer Engineering (Region 7); Sept. 25–28; World Trade and Convention Centre, Halifax, N. S., Canada; C. Robert Baird, Department of Electrical Engineering, Technical University of Nova Scotia, Box 1000, Halifax, NS, B3J 2X4, Canada; 902-420-7717; fax, 902-422-7535.

Visual Communications and Image Processing Conference—VCIP '94 (CAS); Sept. 25–28; Bismarck Hotel, Chicago; SPIE, Box 10, Bellingham, WA 98227-0010; 206-676-3290; fax, 206-647-1445.

Second Workshop on Interactive Voice Technology for Telecommunications Applications (COM); Sept. 26–27; Sumitomo Hall, Kyoto, Japan; Sadaoki Furui, NIT Human Interface Laboratories, 3-9-11 Midori-cho, Musashino-shi, Tokyo 180, Japan; (81+422) 59 3910; fax, (81+422) 60 7808.

International Workshop on Advanced Teleservices and High-Speed Communication Architectures—Iwaca (C, IE); Sept. 26–28; IBM European Networking Center, Heidelberg, Germany; Alfred C. Weaver, Department of Computer Science, Thornton Hall, University of Virginia, Charlottesville, VA 22903; 804-982-2201; fax, 804-982-2214.

16th Electrical Overstress/Electrostatic Discharge Symposium—EOS/ESD (CPMT); Sept. 27–29; Riviera Hotel, Las Vegas; ESD Association Inc., 200 Liberty Plaza, Rome, NY 13440; 315-339-6937.

Wescon '94 (Region 6, et al.); Sept. 27–29; Anaheim Convention Center, California; Electronic Convention Management, 8110 Airport Blvd., Los Angeles, CA 90045-3194; 800-877-2668; fax, 310-641-5117.

Third International Conference on Universal Personal Communications (COM); Sept. 27–Oct. 1; Hyatt Regency Hotel, San Diego, Calif.; Henry A. Macchio, Hughes Network Systems, 10450 Pacific Center Court, San Diego, CA 92121; 619-452-4610; fax, 619-597-8979.

International Professional Communication Conference—IPCC '94 (PC); Sept. 28–30; Banff Centre, Alta., Canada; Pamela R. Kostur, SaskTel, 3-2121 Saskatchewan Dr., Regina, SK S4P 3Y2, Canada; 306-777-2894.

OCTOBER

Sixth Digital Signal Processing Workshop (SP); Oct. 2–4; Yosemite Lodge, Yosemite National Park, Calif.; Mark J.T. Smith, School of Electrical Engineering, Georgia Institute of Technology, Atlanta, GA 30332-0250; 404-894-6291; fax, 404-894-8363; e-mail, mjts@eedsp.gatech.edu.

International Conference on Multisensor Fusion and Integration for Intelligent Systems—MFI '94 (IE, RA); Oct. 2–5; Conference Center, Las Vegas, Nev.; Ren C. Luo, Department of Electrical and Computer Engineering, North Carolina State University, Raleigh, NC 27695-7911; 919-515-5199; fax, 919-515-5523; e-mail, luo@eceris.ece.ncsu.edu.

International Conference on Systems, Man, and Cybernetics (SMC); Oct. 2–5; Gonzalez Convention Center, San Antonio, Texas; Frank DiCesare, Rensselaer Polytechnic Institute, Troy, NY 12180-3590; 518-276-6440; fax, 518-276-6261; e-mail, d0icesare@ecse.rpi.edu.

Military Communications Conference—Milcom '94 (COM); Oct. 2–5; Ocean Place Hilton, Long Branch, N.J.; Harry Carr, AT&T Corp., 8403 Colesville Rd., Silver Spring, MD 20910; 301-608-4400.

International Joint Power Generation Conference—IJPGC '94 (PE); Oct. 2–6; Hyatt Regency Phoenix, Arizona; J. S. Edmonds, MCM Enterprise Ltd., 2755 Northup Way, Bellevue, WA 98004-1495; 206-827-0460.

International Test Conference—ITC (C, Philadelphia Section); Oct. 2–6; Sher-

(Continued on p. 16E6)

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Synchronous DRAMs	16M (x4, x8)	3.3V	180mA	2.5mA	Burst & Power Down Modes
EDO DRAMs	16M, 4M	3.3V	120µA	1mA	Hyper-page Mode; Ext. Ref.; Low SER
DRAMs	16M/4M	3.3V	75mA/60mA	500µA/120µA	Reduced Switching Noise; Low SER; Self Refresh
Flash ICs	1M (x8)	5.0V(V_{PP}=12.0V)	15mA	50µA	Bulk Array; Power Up/Down Data Protection; Ind. Temp.; Volume Capacity
Flash ICs	1M (x16)	5.0V (V_{PP}=12.0V)	25mA	50µA	Wordwide Architecture; Socket Compatible with x16 EPROMs/OTP ROMs
Flash ICs	4M (x8, x16)*	5.0V (V_{PP}=12.0V)	35mA	50µA	32 Blocks (16KB/8K word); Optimized for Data Storage; Auto Program/Erase
Flash ICs	16M (xB)	3.3V (V_{PP}=12.0V)	15mA	0.5µA	Easy Upgrade from Ind. Std. 8Mb Flash Designs; Auto Program/Erase; Deep Power Down Mode; 32 Blocks (64KB ea.)
IC Cards	256KB-40MB	3.3/5.0V	110mA	150µA	Ext. Configurable; 1.4µA Data Ret.; Type I PCMCIA/3.3mm
I/O Cards (10 Base T)	–	5.0V	250mA	–	LAN; Ext. Configurable; Type II PCMCIA/5.0m
I/O Cards (24/96)	–	5.0V	150mA	–	Fax/Modem; Ext. Configurable; Type II PCMCIA/ 5.0mm
Low Power Slow SRAMs	4M (xB)	3.3V	25mA	.4µA	Low Standby Current; Ext. Temp.; TFT Cell
Low Power Slow SRAMs	1M (x8, x16)	3.3V	8mA/15mA	.05µA/1µA	Low Standby Current; Ext. Temp.; TFT Cell
Fast SRAMs	256KB (x8)	3.3V	100mA	100µA	High Performance; Low Power; Ext. Temp.
Fast SRAMs	1M (x1, x4)*	3.3V	100mA	100µA	High Performance; Low Power; Ext. Temp.
Fast SRAMs	1M (x8)	3.3V	100mA	100µA	High Performance; Low Power; Ext. Temp.

*User Selectable

PRODUCT	V_{CC}	I_{CC}	FEATURES/BENEFITS
Baseband ICs	3.3V	16mA (max.)	On-board Scrambler, Compander, Modem
Battery Recharger ICs	3.0/5.0V	18mA/15mA (typ.)	On-chip D/A Converter; Maximizes Battery Life
D/A Converters	3.0V	3.5mA (max.)	8-bit; 12- and 36-channels
DC-DC Converter	2.5V	1.3mA (typ.)	For Backlight Control; Output Short Protection; High Speed Switching (300KHz)
LCD Controller Driver	5.0V	-	Low Power, Dot Matrix LCD Control
Dual PLLs	1.8V	7.5mA (typ.)	410MHz; Various Power Save Modes
Reset ICs	2.5V	1mA (typ.)	Reduces MCU Power Diss; Low Power 2-output; Memory Backup Avail.
GaAs MMICs	3.4V	250mA	B00MHz-1.9GHz Band Operation; 60% eff.; Leadless Pkgs.
0.8µm Gate Arrays/ECAs	3.0V*	–	Very Low Power Diss.; 0.8µW/MHz/gate @ 3.0V; up to 400K Gates
8-Bit LCD MCUs	2.7V	1.6mA (typ.)	Up to 48KB ROM On-chip, LCD Controller
B-Bit Keyboard MCU	2.7V	1.6mA (typ.)	Keyboard Controller, Host Interface
8-Bit MCUs with Custom Logic Functions	2.7V	1.6mA (typ.)	3.0V up to 20MHz clock; User-defined Functions
8-Bit Magicbus™ MCU	2.7V	1.6mA (typ.)	Up to 32KB ROM
16-Bit High Performance MCUs	2.7V	4mA (typ.)	Up to 60KB ROM/2KB RAM or ROM-less; High On-chip Integration

*Fully Characterized for 3.0V

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(Continued from p. 16E2)

aton Washington Hotel, District of Columbia; Doris Thomas, International Test Conference, 514 E. Pleasant Valley Blvd., Suite 3, Altoona, PA 16602; 814-941-4666; fax, 814-941-4668.

Industry Applications Society Annual Meeting (IA, Denver Section); Oct. 2–7; Sheraton Denver Tech Center, Colorado; H. Paul Meisel, Magnetek Corp., 1834 Fillmore Court, Louisville, CO 80027-1122; 303-673-9930; fax, 303-673-9936; e-mail, p.meise@ieee.org.

International SOI Conference (ED); Oct. 4–6; White Elephant Resort, Nantucket Island, Mass.; Witek P. Maszara, Allied Signal Aerospace Co., 9140 Old Annapolis Rd., Columbia, MD 21045; 410-964-4051; fax, 410-992-5813.

12th International Conference on Pattern Recognition (C); Oct. 9–13; Renaissance Hotel, Jerusalem; Shmuel Peleg, Institute of Computer Science, Hebrew University of Jerusalem, 91904 Jerusalem, Israel; (972+2) 585 236; fax, (972+2) 585 439; e-mail, peleg@cs.huji.ac.il.

Bipolar/Bicmos Circuits and Technology Meeting (ED): Oct. 10–11; Marriott City Center, Minneapolis, Minn.; Janice V. Jopke, 6611 Countryside Dr., Eden Prairie, MN 55346; 612-934-5082; fax, 6741.

International Workshop on Active-Matrix LCDs (ED); Oct. 10–11; Hyatt Regency Hotel, Monterey, Calif.; Miltiadis K. Hatalis, Display Research Laboratory, EECS Department, Lehigh University, 19 Memorial Dr., W., Bethlehem, PA 18015; 215-758-3944; fax, 215-758-4561.

Symposium on Low Power Electronics (SSC); Oct. 10–12; Doubletree Hotel at Horton Place, San Diego, Calif.; Lewis Terman, IBM Thomas J. Watson Research Center, Box 218, Yorktown Heights, NY 10598; 914-945-2029; fax, 914-945-1358.

International Conference on Computer Design: VLSI in Computers and Processors (ED): Oct. 10–13; Royal Sonesta Hotel, Cambridge, Mass.; IEEE Computer Society, 1730 Massachusetts Ave., N.W., Washington, DC 20036-1903; 202-371-0101; fax, 202-728-0884.

International Display Research Conference (ED); Oct. 10–13; Hyatt Regency Hotel, Monterey, Calif.; Ralph Nadell, Palisades Institute for Research Services Inc., 201 Varick St., Suite 1006, New York, NY 10014; 212-620-3341; fax, 3379.

Northcon '94 (Portland Oregon Section); Oct. 11–13; Washington State Convention and Trade Center, Seattle; Joan Carlisle, Electronic Conventions Management, 8110 Airport Blvd., Los Angeles, CA 90045; 310-215-3976; fax, 310-641-5117.

Romanian Semiconductor Conference (ED); Oct. 11–16; Sinaia Hotel, Sinaia, Romania; Doina Vancu, R&D Institute for Electronic Components, Bucharest, Romania; (40+1) 633 30 40; fax, (40+1) 312 75 19.

International Carnahan Conference on Security Technology (AES, et al.); Oct. 12–14; Sheraton Old Town, Albuquerque, N.M.; Larry D. Sanson, 186 Woodwalk Court, Nicholasville, KY 40356; 606-223-9840; fax, 606-224-3225.

Gallium Arsenide Reliability Workshop (ED); Oct. 16; Wyndham Franklin Plaza Hotel, Philadelphia; Anthony Immorlica, Martin Marietta Laboratory, Box 4840, Syracuse, NY 13221; 315-456-3514; fax, 315-456-0695.

Gallium Arsenide Integrated Circuits Symposium (ED, MTT); Oct. 16–19; Wyndham Franklin Plaza Hotel, Philadelphia; Donald D'Avanzo, Hewlett-Packard Co., 1412 Fountaingrove Parkway, Santa Rosa, CA 95403-1788; 707-577-2644; fax, 707-577-2036.

International Integrated Reliability Workshop (ED); Oct. 16–19; Stanford Sierra Camp, South Lake Tahoe, Calif.; Tin Yau Ying, The Mitre Corp., 202 Burlington Rd., MS: H113, Bedford, MA 01730; 617-271-8170; fax, 617-271-2734.

Holm Conference on Electrical Contacts (CPMT); Oct. 17–19; Holiday Inn, Chicago City Centre; Holm Conference Registrar, IEEE Technical Activities, 445 Hoes Lane, Box 1331, Piscataway, NJ 08855-1331; 908-562-3895; fax, 908-562-1571.

International Conference on Materials for Microelectronics (ED); Oct. 17–19; Hotel Ferin Palace, Barcelona, Spain; Juliet A. Upton, Institute of Materials, Conference Department, 1 Carlton House Terrace, London SW1Y 5DB, England; (44+71) 235 1391; fax, (44+71) 823 1638.

International Engineering Management Conference—EM '94 (EM, Dayton Section); Oct. 17–19; Marriott Hotel, Dayton, Ohio; Roy Gregg, 448 Merrick Dr., Beavercreek, OH 45434; 513-258-1170; fax, 513-253-9765.

International Conference on Neural Information Processing (NN); Oct.

Calendar

17–20; Swiss Grand Hotel, Seoul, Korea; Iconip '94 Seoul Secretariat, c/o Intercom Convention Service Inc., SL, Kang Nam, Box 641, Seoul 135–606, Korea; (82+2) 515 1560; fax, (82+2) 516 4807; e-mail, ICONIP@cair.kaist.ac.kr.

International Conference on Power System Technology (PE, Beijing); Oct. 18–21; P.Y. Wang, Electric Power Research Institute, Quinghe, Beijing 100085, China; (86+1) 291 3201; fax, (86+1) 291 3126.

Workshop on Power Electronics in Transportation (IE, PEL); Oct. 20–21; Hyatt Regency Hotel, Dearborn, Mich.; V. Anand Sankaran, MD 2036/SRL, Ford Motor Co., Box 2053, 20 000 Rotunda Dr., Dearborn, MI 48121-2053; 313-390-8689; fax, 313-323-8239.

Conference on Electrical Insulation and Dielectric Phenomena—CEIDP '94 (DEI); Oct. 23–26; Arlington Marriott, Texas; Alan Watson, Department of Electrical Engineering, University of Windsor, Box 33830, Detroit, MI 42832; 519-253-4232, ext. 2581; fax, 615-973-7062.

13th Symposium on Reliable Distributed Systems (C); Oct. 25–27; Dana Point Resort, California; Kane Kim, Department of Electrical and Computer Engineering, University of California, Irvine, CA 92717; 714-856-4076; fax, 714-856-4076; e-mail, kane@ece.uci.edu.

Fifth International Conference on Power Electronics and Variable-Speed Drives (IA); Oct. 26–28; IEE Savoy Place, London; Jane Chopping, IEE Conference Services, Savoy Place, London, WC2R OBL, England; (44+071) 240 1871; fax, (44+071) 497 3633.

26th Symposium on Stochastic Systems Theory and its Applications (Tokyo Chapter–CS, GRS, SMC); Oct. 26–28; Mita Press/Osaka, Umeda Center Building, Osaka, Japan; Y. Sunahara, Mita Press, Kyoto Annex, Asahi Karasuma Building 4F 381, Shimizu-cho, Karasuma-East, Takeya, Nakagyo-ku, Kyoto 604, Japan; (81+75) 211 1055; fax, (81+75) 211 1135.

Workshop on VLSI Signal Processing (SP); Oct. 26–28; Embassy Suites Hotel, La Jolla, Calif.; Corey Schaffer, Electronic Research Laboratory, Department of Electrical Engineering, Berkeley, CA 94720; 510-643-6680; fax, 510-642-2739; e-mail, schaffer@eecs.berkeley.edu.

Sixth Symposium on Parallel and Distributed Processing (C, Dallas/CC); Oct. 26–29; Bristole Suites Hotel, Dallas; David Padua, University of Illinois 465-CSRL, 1308 W. Main St., Urbana, Ill 61801-2307; 217-333-4723; fax, 217-244-1351; e-mail, padua@csri.uiuc.edu.

Workshop on Information Theory and Statistics (IT); Oct. 27–29; Holiday Inn, Alexandria, Va.; Prakash Narayan, Electrical Engineering Department, University of Maryland, College Park, MD 20742; 301-405-3661; fax, 301-314-9281.

International Telecommunications Energy Conference (PEL); Oct. 30–Nov. 2; Hotel Vancouver, B.C., Canada; Ed Parker, Northern Telecom Canada Ltd., 150 Montreal Toronto Blvd., Lachine, PQ H8S 1B6, Canada; 514-639-3030; fax, 514-639-3002.

Nuclear Science Symposium—NSS '94 (NPS); Oct. 30–Nov. 5; Waterside Marriott Hotel, Norfolk, Va.; Lowell A. Klaisner, Stanford Linear Accelerator Center–SLAC, Box 4349, Mail Stop: 30, Stanford, CA 94309; 415-926-4463; fax, 415-926-3654.

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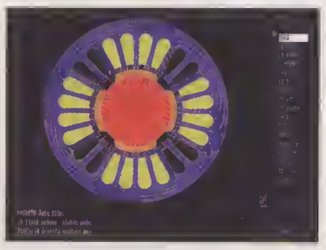

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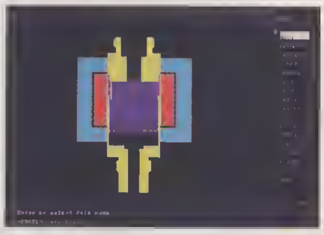

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Calendar

28th Asilomar Conference on Signals, Systems, and Computers (SP, C); Oct. 31–Nov. 2; Asilomar Hotel and Conference Grounds, Pacific Grove, Calif.; James A. Ritcey, Department of Electrical Engineering, FT-10, University of Washington, Seattle, WA 98195; 206-543-4702; fax, 206-543-3842.

LEOS '94 (LEO); Oct. 31–Nov. 4; Sheraton Boston Hotel and Towers; Susan Evans, IEEE/LEOS, 445 Hoes Lane, Box 1331, Piscataway, NJ 08855; 908-562-3896; fax, 908-562-1571; e-mail, s.evans@ieee.org.

NOVEMBER

Third International Conference on Software Reuse (C); Nov. 1–4; Hotel Othon, Rio de Janiero, Brazil; William Frakes, Virginia Tech, Computer Science Department, Northern Virginia Graduate Center, 2990 Telestar Court, Falls Church, VA 22042; 703-698-6020; fax, 703-698-6062; e-mail, frakes@sarvis.cs.vt.edu.

Ultrasonics Symposium (UFFC); Nov. 1–4; Hotel Martinez, Cannes, France; Charles Maerfeld, Thomson Sintra, 1 Avenue Aristide–Briand, 94117 Arcueil, Cedex, France; (33+1) 49 853 100.

Electrical Performance of Electronic Packaging (CPMT, MTT); Nov. 2–4; Monterey Plaza Hotel, California; Paul A. Baltes, Engineering Professional Development, Box 9, Harvill Building., Room 235, 2nd and Olive Streets, Tucson, AZ 85721; 602-621-3054; fax, 602-621-1443.

European Topical. Congress on Technologies for Wireless Applications (MTT); Nov. 2–5; Newlingotto Fair Center, Via Nizza, Turin, Italy; Peter W. Staecker, M/A-Com Inc., 100 Chelmsford St., Lowell, MA 01853-3294; 508-656-2607; fax, 508-656-2777; e-mail, p.staecker@ieee.org.

Frontiers in Education Conference—FIE '94 (E); Nov. 2–7; Fairmont Hotel, San Jose, Calif.; James Freeman, Associate Dean of Engineering, San Jose State University, San Jose, CA 95192; 408-924-3806; fax, 408-924-3818; e-mail, jfreeman@sjsuvmi.sjsu.edu.

16th International Conference of the IEEE Engineering in Medicine and Biology Society (EMB); Nov. 3–6; Omni International Harbor Hotel, Baltimore, Md.; Steve Marlin, Meeting Management Inc., 2703 Main St., Suite 690, Irvine, CA 92714; 714-752-8205; fax, 714-752-7444.

12th International Conference on Computer-Aided Design (C, CAS); Nov. 6–10; Red Lion Hotel, San Jose, Calif.; MP Associates Inc., 5305 Spine Rd., Suite A, Boulder, CO 80301; 303-530-4562.

21st Conference on Industrial Electronics (IE); Nov. 6–10; Hyatt Regency, Orlando, Fla.; C.J. Chen, AT&T Bell Laboratories, Room 3E-2266, 67 Whippany Rd., Box 903, Whippany, NJ 07891-0903; 201-386-3095; fax, 201-386-2942.

Workshop on Motion of Non-rigid and Articulate Objects (C); Nov. 11–12; Marriott at the Capital, Austin, Texas; J.K. Aggarwal, Department of Electrical and Computer Engineering, University of Texas, Austin, TX 78712-1084; 512-471-3259; fax, 512-471-5532; e-mail, jka@emx.cc.utexas.edu.

First International Conference on Image Processing—ICIP '94 (SP); Nov. 13–16; Austin Convention Center, Texas; Al Bovik, Department of Electrical and Computer Engineering, University of Texas, Austin, TX 78712-1084; 512-471-5370; fax, 512-471-5907; e-mail, bovik@cs.utexas.edu.

Workshop on High Performance Electron Devices For Microwave and Optoelectronic Applications (ED); Nov. 14; King's College London, the Strand; Ali A. Rezazadeh, Department of ECE, King's College London, London University, Strand, London WC2R 2LS, England; (44+71) 873 2879; fax, (44+71) 836 4781.

Advanced Semiconductor Manufacturing Conference and Workshop (ED); Nov. 14–16; Hyatt Regency Hotel, Cambridge, Mass.; Margaret M. Kindling, SEMI, 2000 L St., N.W., Suite 200, Washington, DC 20036; 202-457-9584; fax, 202-659-8534.

Topical Conference on the Synthesis and Processing of Electronic Materials (ED); Nov. 14–16; San Francisco Hilton Hotel; Denise DeLuca, AIChE, 345 E. 47th St., New York, NY 10017; 212-705-7344; fax, 212-752-3297.

Third Asian Test Symposium—ATS (C); Nov. 15–17; Nara Ken-New Public Hall, Nara, Japan; H. Fujiwara, Department of Information Processing, Graduate School of Information Science, Advanced Institute of Science and Technology, Nara 8916-4, Takayama-cho, Ikoma-shi, Nara 630-01, Japan; (81+7) 4372 5220; fax, (81+7) 4372 5219; e-mail, fujiwara@is.aist-nara.ac.jp.

Global Telecommunications Conference—Globecom '94 (COM, OEB Section, et al.); Nov. 27–Dec. 1; Fairmont Hotel, San Francisco; Terry Kero, c/o Sprint, 1 Adrian Court, Burlingame, CA 94010; 415-375-4338; fax, 415-375-4079.

Third International Conference on Software Reuse (C); Nov. 1–4; Hotel Othon, Rio de Janiero, Brazil; William Frakes, Virginia Tech, Computer Science Department, Northern Virginia Graduate Center, 2990 Telestar Court, Falls Church, VA 22042; 703-698-6020; fax, 703-698-6062; e-mail, frakes@sarvis.cs.vt.edu.

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Global Telecommunications Conference—Globecom '94 (COM, OEB Section, et al.); Nov. 27–Dec. 1; Fairmont Hotel, San Francisco; Terry Kero, c/o Sprint, 1 Adrian Court, Burlingame, CA 94010; 415-375-4338; fax, 415-375-4079.

Washington watch

Gore team unveils new science policy

Vice President Al Gore unveiled in August a sweeping rationale for research to "maintain [U.S.] leadership in basic science, mathematics, and engineering." With the Cold War long gone as a reason for funding, the new rationale is that basic research, though often hard to justify in the short term, is ultimately good for individuals' prosperity, health, and general quality of life.

"A world without science is a world without hope," declared Gore. But because of tight Federal finances, expect no major budget increases, warned John Gibbons, the President's science and technology advisor. Gibbons spoke at a press conference announcing publication of the 31-page report that describes the new policy.

Called "Science in the National Interest," the document urges incremental rises in Government investment to ensure the "long term health of the R&D enterprise." In 1993, the Government spent US $16.5 billion (or 0.27 percent of the Gross Domestic Product) on basic research; industry, meanwhile, spent $4.6 billion. The report recognizes that industry will continue leaning toward applied research, but urges companies to conduct more fundamental work as well.

Besides leadership across the frontiers of science, Gore's team of advisors set four other goals. The group hopes that a greater emphasis on science, mathematics, and engineering will enhance connections between fundamental research and national goals, and stimulate partnerships to promote investments in science and engineering, as well as produce the finest engineers and scientists for the 21st century, and raise the scientific and technological literacy of all U.S. citizens.

The report is expected to be a "call to arms," according to M.R.C Greenwood, one of its primary authors. She is an associate director in the White House Office of Science and Technology Policy. Gibbons, too, said that he hopes the policy statement will prompt discussion and action. The report is available electronically on the Internet under whitehouse.gov.

All the President's advisors

Concurrent with the science policy unveiling, President Bill Clinton announced the names of the members of the President's Committee of Advisors on Science and Technology (PCAST). The private-sector committee, created by Executive Order last November, is to help prioritize government research.

PCAST is co-chaired by John Gibbons, the President's science advisor, and John Young, former chief executive officer of Hewlett-Packard Co. Included among the other 16 members are Norman Augustine, chairman of Martin Marietta; Murray Gell-Mann, Nobel Laureate and professor at the Santa Fe Institute; Sally Ride, director of the California Space Institute; and Charles M. Vest, president of the Massachusetts Institute of Technology.

(Continued on p. 60T1)

Reflections

No more lunch

Some readers may remember the debate that took place some 15 or 20 years ago about what we would do with our expanding leisure time. The futurists of those days assured us of the inevitability of a four-day workweek. They predicted that as the hours on the job shrank we would be hard pressed to find enough other activities to fill all our free time.

Now it seems that wherever I go in professional circles people are asking each other whether they are working harder and enjoying it less. They ask in a kind of rhetorical way, and I sense that they simply want assurance that they are not alone in facing mounting job pressures and demands for longer hours of work and greater commitment.

The job pressures in recent years have been exacerbated by the rise of global competition and the economic downturns that have led to the popular fashion of "downsizing." It has gotten so that you're afraid to leave your desk on a Friday in case it may not be there on Monday. Meetings start earlier, and get scheduled later into the day and even on weekends. I heard of one case where a manager scheduled a meeting for 4:30 a.m., as the only time that he had available. Engineers at most companies are expected to greet these demands with silent equanimity. Many, if not most, of these engineers fall into the "exempt" category of employee—meaning that they are exempt from being paid for overtime. How fortunate this is for the company.

Let me imagine a scenario at Acme Engineering, where the top executives are meeting to assess the state of their business. We might envision the group gathered around a long table and concentrating upon a large chart showing the profitability of Acme. The jagged line slopes ominously downward. "We've got to cut expenses," moans a vice president known for his keen analytic insight.

Of course, the alternative of increasing revenues would never occur to these executives. Expenses are something you can control, and when the engineers last promised expanded revenues with an enhanced widget, profits did not rise as predicted. Furthermore, the stock analysts will applaud an expense-reduction program.

The chief financial officer presents the expense analysis. The many tables of fine print and the familiar computer-generated pie charts pinpoint the major source of expense—employee salaries and benefits. The other officers nod their heads in grim acceptance of this fundamental insight. Acme clearly needs fewer employees and more work per person from those who are so fortunate as to remain. Thus the plan put forward is to cut the payroll by 15 percent, with no loss of Acme output. How simple it is when you apply your talent to a problem!

The executives wordlessly concur with this plan, feeling all the satisfaction of being tough-minded decision-makers whose compensation depends on stock price performance. The only remaining question is how to ensure that the remaining 85 percent of the workers become 15 percent more efficient.

Gary Hovland

"We told them that they had to work smarter last time," complains one of the vice presidents. "And I don't see any evidence that they listened to us," he continues. "Why, just yesterday I was noticing how empty the offices were at noon, like everybody thought they could go on a picnic or something while the company founders."

Another vice president expresses bitter agreement. "I don't think they really care about Acme," she says. "Just as we gain some momentum with the morning work, they're off for lunch like they don't have a care in the world. If they understood our business situation, they would work right through."

The financial officer, who is good with numbers, is suddenly alert. "If the lunch hour were eliminated, that would be a 12.5 percent increase in productivity, which would take us a long way toward our goal," he says tentatively.

After a small, thoughtful silence, a number of subdued conversations break out. As the meeting gradually returns to order, the decision seems to have been made without actually being stated—the lunch hour will be eliminated. The president turns to the corporate communications person, and orders that a desk-to-desk announcement be prepared for immediate release.

This is where the talents and training of the corporate communications department come to the fore. Proper spin must be applied with the utmost skill. The announcement, as is customary, must be contentless and upbeat. This instance is certainly a challenge, but the dedicated employees in corporate communications will gladly work through their lunch hour today in order to prepare the notice.

"Acme Announces Employee Fulfillment Plan" is the headline.

"President Green today announced a new corporate plan, to be designated EFP, that will enable all Acme employees to attain greater individual effectiveness by permitting them to share more fully in the success of Acme. Under EFP, which will be effective Sept. 15, employees will be allowed to conduct normal working activities during that portion of midday which has previously been underutilized because of the enforcement of lunch time diversions. EFP will remove the restrictions on the use of this time so as to enable employees to seek a greater self-fulfillment consonant with a stronger and more profitable Acme.

'This is a win-win situation,' says President Green. 'Acme employees will achieve health benefits from less calorie intake and lowered cholesterol, and will experience an expanded sense of self-worth, while Acme's increased competitiveness will move it toward an ever greater role in our industry. The officers and I are pleased to be able to share this plan with our dedicated Acme employees.'

"EFP will also enable the expansion of the popular Acme employee information center into the space vacated by the cafeteria facilities."

Coinciding with the news of the downsizing program, learned only from that morning's national newspaper, the desk-to-desk announcement of EFP is greeted with perplexity and stoicism. The typical comment is "Huh?" After all, what can you do? This is the way it is.

So much for my fantasy. Of course, nothing like this happens in real life.

The way things are going, however, the words of Harry Chapin's haunting song "Cat's in the Cradle" keep running through my mind. Your children grow up ("little boy grows into man") while you're away on a business trip. But what can you do? This is the way it is.

Robert W. Lucky

Program notes

DOS lives on

Reports of MS-DOS's death have been greatly exaggerated. Even though DOS's originator, Microsoft Corp., has announced that the operating system's heir apparent will be available in early 1995, users remain fervently interested. One-fifth of the PCs sold this year will have only DOS installed.

The 20 million or so computers based on 286, 386SX, and slow 386DX microprocessors are a profitable marketplace for developers willing to focus on low-cost solutions to existing user needs. Borland International Inc., for example, recently discovered that four out of five programmers using Borland C++ 3.1 planned to create new DOS applications and upgrade existing ones as well as create Windows applications. Many did not want to switch to Borland's new "visual" C++ because it offered little support for writing DOS applications.

Borland responded to developers' demands for better DOS tools by introducing the Borland PowerPack for DOS. This add-on collection of tools made Borland's new compiler a superb development environment for creating DOS applications. One PowerPack tool was created specifically for DOS developers who plan to migrate their applications to Windows at some point in the future. Programs written using the tool can later be directly compiled as Windows applications without changes. The US $499 PowerPack also doubled the revenue Borland received with every compiler sale.

Tens of thousands of existing DOS applications not yet duplicated in Windows also point to a profitable niche marketplace. Developers willing to provide tools that enhance the link between new graphical operating environments and DOS applications, particularly Windows and DOS, will find eager customers in these markets.

Windows 3.1 and Windows NT 3.1 do not run large DOS applications well, and Microsoft's forthcoming operating systems, code-named Daytona and Chicago, may perform even more poorly, according to early evaluations.

Third-party developers who can create tools that enhance the behavior of DOS programs under Windows will open an ample revenue vein as the program users switch to Windows. Phar Lap Software Inc., the original developer of DOS extender technology, has produced a Windows Program Manager replacement called FrontRunner. FrontRunner enhances DOS programs with Windows features like cut-and-paste and a 16 000-line history capability. It also gives users a DOS-like batch language capability inside Windows.

These new packages developed by Borland and Phar Lap illustrate the potential still present in the DOS market. Many computing needs can be fulfilled more quickly and cheaply in DOS than Windows. Small developers should look for other unexploited niches that they can profitably exploit during the (estimated) two to five years left to DOS. *Contacts: Borland International Inc., 100 Borland Way, Box 660001, Scotts Valley, CA 95067-0001; 408-431-1000; or* **circle 101**; *Phar Lap Software Inc., 60 Aberdeen Ave., Cambridge, MA 02138; 617-661-1510; or* **circle 102.**

Application as environment

Lotus 1-2-3 was the first application that freed users from having to deal directly with the operating system; they could find files and even format disks from within 1-2-3. That original concept has spawned applications suites like the Microsoft Office or Lotus SmartSuite that by-pass Windows to integrate applications.

The strength of this approach is that users need learn only one set of key strokes and one set of mouse point-and-clicks to run a word processor, a spreadsheet, and a database. The weakness of the application suite is that all the modules come from the same vendor. Some are great, some average, some not so good.

Microsoft offers users a tool to substitute alternatives for unwanted elements of the Microsoft Office. Office supports "component software," plug-in modules that can be added to Office as another entry on pull-down menus.

Third-party developers with existing Windows applications can purchase a Microsoft Office Developer's Kit. It contains code that imparts an Office look-and-feel to the developer's application and allows it to link with Word, Excel, and PowerPoint as an option on a pull-down menu.

ShapeWare's Visio Express is the first commercially available software component for Office. Express is a simplified version of Visio's award-winning drag-and-drop drawing package at a price ($79) most users will be willing to pay. It gives Excel, PowerPoint, and Word users two drawing options, Microsoft's Draw or ShapeWare's more powerful Express.

Everyone benefits from the component software concept. Microsoft is no longer under pressure to upgrade Draw, since a low-cost alternative is available. Visio generates revenue from Office users who would not purchase the full Visio package. And users get a good drawing tool at a low cost. *Contacts: Microsoft Corp., One Microsoft Way, Redmond, WA 98052-6399; 206-882-8080; or* **circle 103**; *ShapeWare Corp., 520 Pike St., Suite 1800, Seattle, WA 98101-4001; 206-521-4500; or* **circle 104.**

Novel debugging tools

Identifying and correcting bugs is much easier now than in the past. Entry-level products like Turbo C++ and Visual Basic have built-in source-level debuggers that would have cost thousands of dollars five years ago. Today's advanced products are typically shipped with debugging tools whose capabilities were unimagined only two years ago. Unfortunately, the complexities of operating environments and applications have increased even faster than debugging tools.

One way to debug programs is to avoid writing bug-prone code. Two recent Microsoft Press books offer advice on this topic. The first is Steve McConnell's *Code Complete, A Practical Handbook of Software Construction.* The subtitle tersely describes the book's focus. It is a "big-picture" book that uses case studies to introduce problem-prone techniques and how to avoid them. The book even has checklists to assess key program features like architecture, layout, and test cases.

The second is Steve Maguire's *Writing Solid Code*, a nuts-and-bolts book that discusses techniques for detecting and preventing bugs. Every working programmer should own both books.

Another way to debug programs is to use tools that apply new, automated techniques to finding and detecting bugs. One such tool is Nu-Mega's Bounds-Checker, which watches how programs with debugging data in either CodeView or Turbo Debugger format behave. The tool comes in DOS and Windows versions: the DOS version looks for invalid memory accesses, string and buffer overwrites, and resource and memory leaks; the Windows version also validates Windows API calls and logs Windows events. *Contacts: Microsoft Press, One Microsoft Way, Redmond, WA 98052-6399; 615-793-5090 (800-MSPRESS in the United States); or* **circle 105**; *Nu-Mega Technologies Inc., Box 7780, Nashua, NH 03060-7780; 603-889-2386; or* **circle 106.**

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Roundtable debate: Upgrading the information infrastructure

If digital information is to be the lifeblood of society, then a society that wants to thrive should allow all of its citizens reasonable access in their pursuit of knowledge. The U.S. government has made this objective an organizing principle of its infrastructure policy. In debating this topic, the discussants point out that providing such universal availability is a much more complex issue than providing universal telephony. In few other areas are technology and business interests so entwined with social issues. Not surprisingly, opinions are strongly held. Some participants here even propose the idea of "byte stamps," by analogy with the food stamp program to aid the hungry.

The panelists and their groups' activities were:

Jim H. Beall *(M), senior vice president of systems and operations at Prodigy Services Co., White Plains, N.Y., the largest consumer computer network. He is also on the Federal Networking Council Advisory Committee.*

Bernard B. Bossard *(M), cofounder and chief engineering officer of CellularVision of New York, in the city of that name, which seeks to offer very broadband communications directly to the home.*

David J. Farber *(SM), Moore Professor of Telecommunication Systems at the University of Pennsylvania, Philadelphia. He is on the board of the Internet Society, America OnLine, and the Electronic Frontier Foundation.*

Elwood Kerkeslager, *AT&T Corp. vice president for information infrastructure policy. He began his career as a programmer and circuit designer with Bell Laboratories.*

Matthew D. Miller *(M), head of technology at General Instrument Corp., Chicago, principal equipment supplier for cable and satellite television. His prior experience was with Viacom International and RCA Sarnoff Laboratories.*

Michael R. Nelson, *the White House's main information infrastructure staffer. He previously worked with Vice President Al Gore in the Senate on issues like the High Performance Computing bill.*

Janice Obuchowski, *founder of Freedom Technologies, a telecommunications consulting firm in Washington, D.C. As head of*

John A. Adam Senior Associate Editor

(Photos) Jim Pickerell

Discussing how the information infrastructure is set to change, Woody Kerkeslager [left], AT&T Corp., and Matthew Miller, General Instrument, share their opinions during a roundtable convened by IEEE Spectrum in Washington, D.C. Participants compared notes on how the regulated, relatively slow-moving communications industry and the historically innovative and rapidly moving computer industry would try to converge.

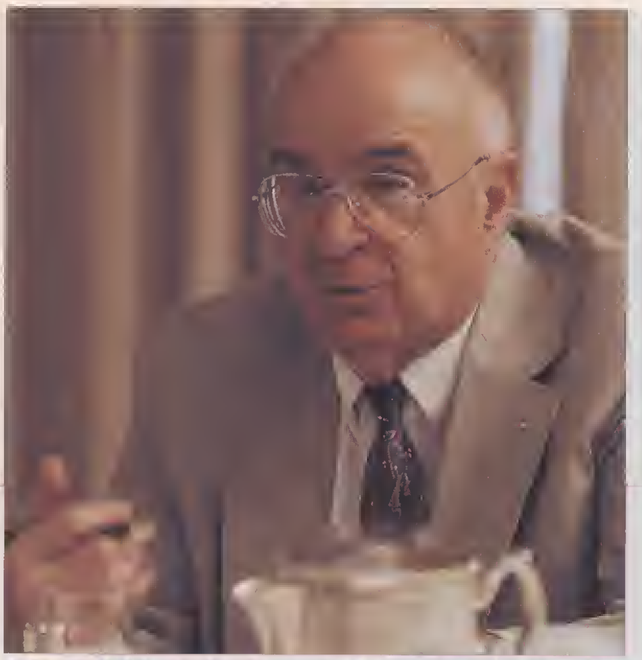
Eavesdropping on infrastructure experts

IEEE Spectrum convened a group of 10 technologists and policymakers at the historic Willard Hotel in Washington, D.C., on June 28, with the charter of discussing issues involved with upgrading the information infrastructure. Besides three policymakers from the Federal government, participants included two academics and five industry representatives—one each from the local phone company, long-distance carrier, cable television, wireless, and computer network arenas [see above].

No agenda was set. No consensus was sought. The basic goal was to eavesdrop on a group of experts. David Farber, Moore Professor of Telecommunication Systems at the University of Pennsylvania in Philadelphia, moderated when necessary.

Presented here are edited highlights of a 133-page transcript of the 3-hour session. The article begins with comments on access and universal service. Discussions on standards and intellectual property rights begin on p. 27. (An additional report on the information infrastructure incorporating additional remarks made by roundtable participants will soon appear in *Spectrum.*)

The transcript and full biographies of participants are available as an auto-retrievable file to anyone sending a message on the Internet to: info.pub.roundtable@ieee.org. Participants were allowed to review an edited version of the transcript for accuracy and currency at the end of July. The views they expressed are not necessarily those of their organizations.



Informed debate about universal service and access has been lacking.

—*David Farber, University of Pennsylvania*

The Government needs to be more of a catalyst in an industry-based standards-setting process.

—*Arati Prabhakar, NIST*

the U.S. National Telecommunications and Information Agency, she was a primary advisor to President George Bush.

Arati Prabhakar *(SM), director of the U.S. National Institute of Standards and Technology (NIST). She chairs the Information Infrastructure Task Force's committee on applications and technology.*

William L. Smith *(M), who heads BellSouth Corp.'s infrastructure deployment in the North Carolina Information Highway Initiative. He also participated in development of the asynchronous transfer mode (ATM) standard.*

David L. Tennenhouse *(M), an associate professor at the Massachusetts Institute of Technology's Laboratory for Computer Science, Cambridge. His interests include networking, multimedia, and information infrastructure.*

The infrastructure is there so that much of the United States could have upgraded multimedia services soon.

—*Jim Beall, Prodigy*

Competition with flexible and minimal regulation will be the guiding principle in setting up the new infrastructure.

—*Mike Nelson, White House*

Serving people

DAVID FARBER: Access—who has it, what is it, at what cost—is a topic that all of us seem concerned about.

MICHAEL NELSON: We should distinguish between two things. One is the universal service question: how do we make sure that everybody is connected to the network, and has the ability to get service if they want? This is an old issue. We've dealt with it for more than 60 years in the telephony world.

Then there is the open access issue: how do you make sure that people who have a service to offer can get up on-line and provide programming, data services, or information that they want to make available? They're somewhat different issues and with this Administration, we've had hearings on both.

Universal service is fundamental to what we're trying to accomplish. We want to have the same kind of universal offering in the broadband digital world that we've had in the telephony world, where 93 percent of all Americans have telephone service. We've set up regulatory structures and subsidy systems that ensure that most people can have affordable telephone service, and we'll need to do some of the same things in the new world of digital broadband networks.

The difference, of course, is that in the past we had a monopoly phone system, which we could regulate, specifying exactly how universal service should be provided. In the future we'll have many players in the marketplace and yet we'll still need to

What's really going on here is a change in the framework—the new world is much more dynamic.

—David Tennenhouse, MIT

Engineers will create needed innovations if left unshackled by regulations and standards.

—Bernard Bossard, CellularVision

accomplish the social goal of allowing everyone to interact with everyone else.

I'm willing to pay a little extra on my phone bill because I want to ensure that I can talk to my Aunt Caroline in rural Minnesota, and many people and many businesses are also willing to pay extra so they can reach almost every American. But to ensure that we meet that goal with the new system, we need to design it intelligently, with a minimum of regulation.

JIM BEALL (Prodigy senior vice president): The problem is so broad that maybe we should start by defining it. First, there's access to services, which probably applies to all of us when we think of our personal lives. Then there's the ability to offer services, which applies to someone who wants to start a business doing that.

Deciding what kinds of services can be offered and which people can receive them is complicated by the bandwidth issue. If more people had the experience of living with ISDN [Integrated-Services Digital Network] for a week, there'd be a lot more demand. ISDN is an infrastructure that is already in place throughout the country. However, even where it is available, it is not generally at an affordable price. Even though ISDN is far from the answer to our needs in the longer term, it is so much better than what we have now. Something like 60 to 70 percent of the exchanges in the country are, or soon will be, ISDN-capable.

BERNARD BOSSARD (chief engineering officer of CellularVision): That's still slow.

BEALL: It's slow, but it's a giant leap from where we are today.

WILLIAM SMITH (BellSouth participant in the North Carolina Information Highway Initiative): One of the biggest challenges is defining what it is. "Information infrastructure" itself is the most overused and under-understood term. What we are looking at in North Carolina is geared toward institutional users, but that may be, in fact, a different technology, a different platform, than an entertainment-type service.

So I think defining it is part of the problem. In North Carolina, the Governor's office policy is to try to put access to the information highway near users or closer to them, but not necessarily assign an OC-3 [155.5-Mb/s Optical Carrier] channel to every home.

For example, public libraries are looked at as an avenue for this purpose. I don't think you have to have a fiber into your home to be affected by the information infrastructure. If you have better quality education, health care, economic development, then you've been affected.

WOODY KERKESLAGER (AT&T Corp. vice president): The issue is allowing competitive markets with open public interfaces, through which any provider of devices in the home or the office can connect to networks. That way there's a platform you can plug into, or be assured that, if you design to those interfaces, you can connect with those networks.

And on the other side of the networks, I'd like to propose the same model: information providers of any kind should be able to plug into open public interfaces so that they have a platform with which to work in reaching the consumers and businesses and universities.

With a model like that, you have a free market where the information providers decide whether to provide broad- or narrowband services, voice or video, because I think we need to keep coming back to the consumers, the businesses, and say, what do you want, what is useful to you?

I'm concerned about our elitism when we say we must have broadband everywhere or we must have this or that. We should check it with the marketplace and with the public policymakers. When we talk about what base line everybody should have, that's a major public policy debate that needs to be led by the same people who've worked on the telephone issues to determine universal service.

MATTHEW MILLER (technology head at General Instrument Corp.): I think there is a problem in bringing up a point of view in terms of a Federal highway or the public switched telephone. In either case, a central authority seemingly sets the rules for everybody.

It's wonderful that AT&T is going to have public infrastructures for the equipment suppliers and the information providers to plug into. But how many switches are there going to be? And what do you do when you start running out of capacity at the switch, and somebody occupies the last port on the switch? Because bandwidth isn't infinite—it never

Providers should be able to supply any number of bandwidths to the home.

—*Woody Kerkeslager, AT&T Corp.*

We've had situations with ISDN where an AT&T switch can't talk to a Northern Telecom switch.

—*Bill Smith, BellSouth*

Where do you draw the lines of demarcation in a distributed network?

—*Matt Miller, General Instrument*

was—and bandwidth isn't free—it never was.

How do you decide who's next? So it's not quite as easy as you thought. Just because you've got public interfaces doesn't mean that you've got a competitive environment in all the areas that require it.

Next, universality. We have such a complex definition of "service"—to your point, Bill [Smith]—that I think it's going to be virtually impossible to define what, as a matter of public policy, should be universally available. In the good old days, it was easy: give me 3 kilohertz and let me make a phone call. Today, we don't even have universal access to ISDN, for crying out loud.

FARBER: It wasn't quite that easy.

MILLER: Even that wasn't easy. For instance, consumers are going to become producers as well. So is it going to become universally possible for anybody to put 1.5 Mb/s of compressed video back into the network at an affordable price, with whomever deciding what "affordable" means? We'll go crazy. I don't have the answers, but I think I took care of everybody who went ahead of me.

DAVID TENNENHOUSE (associate professor at MIT): Many say people at home don't want to generate, or source, information. Well, the truth is we have CD players at home, we have cameras, VCRs, etcetera. We have a rich information infrastructure in our homes. Once that becomes digital and is unlocked, people will find that they have plenty of source material to contribute. So the question is: how do we dynamically allocate resources to enable that?

What's really going on here, I think, is a change in the framework in how we think about resources, bandwidth, in particular. The traditional model is a very static allocation of resources: we run a twisted wire to everybody's house, or we statically allocate a telephone channel to a broadcaster.

The new world is much more dynamic. We can constantly reallocate the bandwidth on a microsecond-to-microsecond basis.

One thing we can agree on is that universal service no longer means the universal deployment of a single technology—and the rapid pace of innovation makes the old concept of universal deployment impractical. Different technologies will be used in each town and neighborhood. Even next-door neighbors may be served in different ways.

So we have to separate the regulation of information services from the technologies by which they are distributed. As a society, we may consider universal telephone service to be a "necessity of life." The ability to place telephone calls is the service to be regulated—the distribution technology is irrelevant. (Surprisingly, the cheapest way to deliver an emergency telephone service, such as Lifeline, may be wireless. Wireless resources are only consumed while calls are in progress. For extremely low-volume users, the standby cost of wireless is negligible when contrasted to the cost of wiring homes.)

ARATI PRABHAKAR (NIST director): Things will change in the next five years that just completely overshadow the changes in the last 50 years and the pace is really unprecedented. So it's great to figure out what the answer is today, the access or universal service question, but it's also pretty irrelevant if you're not on the technology curves.

Universality issues

NELSON: I'd like to get specific here on universal service. We might not agree on what services are to go to everybody, but we should be able to agree on the minimum bandwidth that should be universally available. If you don't have enough bandwidth coming into and out of your home, then you won't be able to do many of the two-way video applications that everybody is talking about.

I wonder what the industry means when it talks about setting a goal of universal service by a certain level by a certain year. What makes sense? Is it ISDN to all? Is it something else?

KERKESLAGER: Two comments. When I talked earlier about platforms, about open public standards providing competitive markets on both sides, I gave an example of the competitive market in information appliances. That applies equally well to information networks working into those open public interfaces. It does not specify bandwidth. It does not say 1.5 Mb/s to the home.

It says, if suppliers see a market for 100 b/s to the home, they can go after it, and if they see a market for 1 Gb/s, they can go after that. So the key is to set up the interfaces, and whatever the standard is, make it an open public standard. Intellectual property rights associated with it are just fine.

If you do that, you create competitive markets. It applies to the interfaces between networks and information appliances and the networks between information service providers. It provides the capability for the technology you want, David [Tennenhouse]. Any technology can be applied by consumers.

It also applies to a potential supplier so he or she can create a service or technology and be the next Andrew Carnegie or Bill Gates.

When you go beyond that and start the universal service debate with a presumption that bandwidth to the home should be specified, we're selling ourselves short. That is the wrong direction to go, Mike [Nelson], because many of us may need basic voice, basic access to information.

And with the advances in compression and so on, perhaps ISDN is more than adequate. So that should be a subject of public debate. By the way, I'm a big believer that when you open them up, we will have more than just one or two interfaces; we will have lots of providers into the home competing through the air and through facilities.

NELSON: Let me clarify something. I'm not saying that the government should tell information or telecommunications service providers what to provide where. That's a supply side answer, a top-down answer, with the government calling the shots.

A much better question is: at what point should government play a role? At what point should we develop a regulatory structure or a subsidy system that ensures that people have a minimum level of service?

KERKESLAGER: A one-sentence answer: I think it's government's role at the state and Federal level to determine the needs of consumers that it considers universal, and that means service needs.

NELSON: But it's a very different approach than what's been done in the past.

MILLER: The last damn thing in the world I would want would be to have the government running focus groups on what consumers want. I don't know how you do it, but I know that's how you don't.

NELSON: The government does have a role in deciding what public services will be available to all people and whether we should fund digital textbooks for school kids, for example.

MILLER: Absolutely.

NELSON: And we need to understand as a government whether we should be spending money to ensure that people have access to these new digital services, and I'm wondering what you all think is the bare minimum in this digital world.

BEALL: We ought to have the availability of high bandwidth, at least 1.5 Mb/s at home if you want it. Now, you can step that down and maybe for a different price you can get ISDN at 64 kb/s or you can get some other service at 28 kb/s.

KERKESLAGER: Try as we may, we cannot wish universal service away and say that it concerns just the communications or telephone industry. If the government believes some communications capability, whether it's telecommunications or NII [National Information Infrastructure] communications, to be important to the broad population, then it's government's role to work with industry to determine what those universal service attributes are and find a way to tax to provide those services.

Small companies are hurt most by slow government implementation of regulation.

—Janice Obuchowski, Freedom Technologies

TENNENHOUSE: Once we decouple the regulation of the services from the distribution technology, a lot of these universal service issues will be simpler.

Competition and volume may drive the price of services down to the point where most consumers don't need protection. A lot of these services may end up like food. We have a public policy that people should not go hungry. The market brings the price of food within the range of most consumers. Food stamps fill in these gaps. It's a fairly effective system, decoupled from the distribution of the products.

NELSON: That's how we're moving as a government. It's focusing on the demand side rather than focusing on the supply side.

KERKESLAGER: Continuing with the food analogy, the government determined that because food is important, it would provide food stamps to those in need, and it told them: "Go get food; I don't care within a reasonable range what you buy for nutrition, but here are the stamps, go get food."

If we determine that information infrastructure is important—if not as important as food—we will give individuals the capability to buy in a free and open market. So rather than telling the supplier that you must artificially lower your price or subsidize your service, we let people buy in a free and open market, which furthers competition.

That's the way we look at universal service and the right way to do it, not by taxing industry, but by taxing broadly to do it.

MILLER: So do we have byte stamps?

KERKESLAGER: You can make jokes about what it is, but hopefully the universal service definition will be more thoughtful, more of a public debate.

FARBER: It hasn't been very thoughtful to date.

JANICE OBUCHOWSKI (Freedom Technologies founder): From my vantage point, if we move to competition very quickly, at least 85 percent of the debate about universal service will be solved because prices will come down, at least within reach of the working population. Then the essential role of government, providing for the 10 to 15 percent of society unable to afford access, is manageable.

Bandwidth scarcity is an absolutely transitional argument. The sooner we interject no-holds-barred competition, the sooner we'll get that "unlimited" bandwidth. People who have a vested interest in some *status quo* will fight to retain that while they catch up into the next generation of technology. And the sooner we get out of the way of allocating market share, allocating industry, the sooner we'll see that bandwidth.

NELSON: Just two sentences on what Janice said about getting the price down to everybody. The Vice President made very clear that the very first step on universal service is more competition and lower prices. Nothing would do more to achieve our universal service goals than cutting prices by 50–80 percent. And I think we're going to do that partly with the legislation in this Congress.

BEALL: A final comment on universal service. Economically disadvantaged areas are clearly one problem. But the other is rural America. Our service coverage omits

about 20 percent of U.S. households because we cannot economically provide them with local call coverage. So that's a big problem, which has nothing to do with where people are on the social scale.

Appropriate standards

Standards and the process by which they are set were visceral issues during the roundtable. Some said standards were stiflers of innovation, ways to pirate technology legally [see "On intellectual property," right], and a potential threat to U.S. industry. Others described them as being key to lowering costs and making the information infrastructure truly global. Many nuances were evident, like maintaining cultural characteristics in an international digital world. In short, if you believe that standards are a dull topic, an issue for someone else, this exchange could change your perception.

SMITH: The proliferation of different standards and approaches drives costs up. The cost of ATM [asynchronous transfer mode] equipment is falling today in large part because there is in fact one standard and people are beginning to mass-produce. We can't overlook the effect of standards and technological issues on the economic side of the equation.

BOSSARD: Regulations and standards are generally based upon the existing infrastructure and what is perceived as the state of the art. Underestimates have thus occurred. For example, television standards, with their limitations of 6-MHz bandwidth per channel, make it difficult to achieve the quality performance necessary for high resolution and large screen receivers required by the 21st century interactive information superhighway. At the time TV standards were developed, FM, with its quality and maximum frequency reuse, was not fairly considered and the marketplace was focused on rather small TV screens.

If you ask this enlightened group to write down what they feel the standards should be, a twisted-pair person might say ISDN or 64 kilobits, while another person might say one gigabit per second. In reality, the answer is based on the characteristics of the propagation medium (wire, fiber, cable, wireless, or others) and will differ widely. It should depend on the future needs of the marketplace as well as the majority infrastructure presently in place. Monopolies generally need not provide new desired services until their aging infrastructure is replaced. Competition, not regulation, solves this a problem and accelerates the solution to the advantage of the consumers.

The way the FCC [Federal Communications Commission] regulated satellites was brilliant. They didn't regulate usage or satellite orbit spacing except by interference criteria. The prevailing wisdom at the time—only a few years ago—was for satellites to be spaced no closer than 4 degrees. Today we're down to 2 degrees. So I'm not worried about the ability of the engineering and software people to develop all kinds of creative interactive systems. I am worried that we could prejudge those systems, prestandardize them, and therefore inhibit their existence.

FARBER: I think what you're saying is that the market-determining factors are a better way than standards. If you just look at almost every case of standards set before the fact, they've been failures, certainly in the computer industry and probably in the computer communications industry, too.

BEALL: On the subject of interface standards, you'll probably need much more than a simple definition. We've found that as the

On intellectual property

The rights of authors and inventors were something so fundamental that recognition of their creative work was included in Article 1, Section 8, of the U.S. Constitution. Finding a way to ensure that these groups will be properly compensated for their toil is key to a vibrant information infrastructure in terms of both tools and content. Two academics speak first; then two company technology heads pitch in.

DAVID FARBER: One problem of creating businesses on the net, these structures, whatever you want to call it, is determining whether anybody may sell anything more than once, the intellectual property problem.

We cannot waive that, because we're all assuming that somehow a market out there is just waiting to sell things [over the net]. Yet, when I talk to people, they say: "Me put my precious magazine article on this? Never, until I can find a way to collect for it."

DAVID TENNENHOUSE: Once again, we come back to the fundamental decoupling of services and distribution. In the case of intellectual property, this means the decoupling of information from the media on which it is distributed. In the digital age, the cost of the distribution medium is in free fall, but so is the cost of pirating.

There are two issues here that need to be distinguished. One is labeling information with copyright notices that tell law-abiding citizens what they can do, how to pay royalties, and so on—you have to make it easy for people to do the right thing. Enforcing the laws is a separate issue. Independent mechanisms can be used to detect theft and punish offenders. We have a fairly good system of policing and courts—engineers don't have to solve all these problems with technology.

Many people claim that the protection of intellectual property is one of the issues that will hold back the whole NII [National Information Infrastructure] effort. I think that as soon as people believe they can make a decent profit, they'll get out there and try to sell their information. Once they do that, we'll find out where the theft occurs and what preventive measures are appropriate. The cost of protection has to be balanced against the potential loss—until you learn what the rate of loss is, it's hard to say how much should be spent on prevention.

MATTHEW MILLER: Enforcement is a scarce commodity. Our business is security and access control and encryption of copyrighted material, and people get angry at us sometimes because they are accustomed to getting television for free and they don't like paying for it. And we have fought a 10-year battle in the home satellite market maintaining security there.

But I will tell you that enforcement isn't based on finding the people violating the laws but on our ability as the providers of the locks to keep on changing the locks and the keys.

TENNENHOUSE: But because you're in the business, you're able to balance the cost of the locks against the revenue.

MILLER: Absolutely, positively.

TENNENHOUSE: That's critical.

MILLER: Yes. And in fact, an important issue is—I'm going to use something here that resembles a common carrier analogy. There are lots of trucks in this world and many different cargoes that go on trucks. I put a different kind of lock on a newspaper delivery truck from the one that I put on a money delivery truck, and somewhere along the line the guy whose stuff is going into the truck should have something to say about the level of security around it. And that goes to your point about security on the network. The content provider has got to have some say about the way in which his content is secured.

WOODY KERKESLAGER: I'd like to talk about intellectual property and standards. The United States is a leader in protecting intellectual property because it's a leader in R&D. At the universities and in corporate laboratories, we develop intellectual property and this is frequently embedded in standards—standards that define interfaces.

Let me quickly frame an issue of global importance. We need to have open public interfaces, but also to allow intellectual property to be associated with an interface, or else you will not have research and development that creates the new technologies and the possibilities of those interfaces.

Some people believe no intellectual property should be associated with an interface. Virtually all those people are outside the United States.

MILLER: People spend a lot of time worrying about the IPR [intellectual property rights] for the content providers. We can't overlook IPR for inventors. In my company, we spend $100 million a year on R&D. The only way we make our money is getting paid back for that R&D.

Every time we get into an international standards discussion, the first thing the guys who don't have what we've invented want is an open architecture.Well, one man's open architecture is another man's confiscation of intellectual property, and there's a big difference between an open architecture and a royalty-free license for use.

KERKESLAGER: We agree on that one.

bandwidth goes up, the application changes so dramatically that the interface may not hold. You need a complex definition to deal with the application possibilities that are available. If we get too confined, if you regulate before the innovation, it will not come out correctly.

KERKESLAGER: The standards process, starting at the physical layers and going up as far as you need, should not encroach on innovation.

MILLER: The problem is, you have a distributed network. It's easy to think in terms of a standard like the RJ-11 jack in a public-switched phone system. There's a hole in the wall and it's owned by the telephone company on the left side and by the consumer on the right side. You've just got four wires and you decide what they look like and what the physical configuration is.

KERKESLAGER: The same thing as with the cable, right?

MILLER: Not any more. Cable will wind up very complicated. There're going to be switched services, broadcast services, software that comes out of the network, and software that originates from the home. There's going to be local-area routing.

One of the problems is that in a distributed network nobody knows where to draw the lines of demarcation. There are multiple layers in the delivery of programming where standards will need to be set, and they'll get set in different ways. Sometimes they'll be *de jure* set by some committee.

I'm a believer in *de facto* standards where volume sets the standards. But it is more difficult than we think in an environment where you have the intelligence distributed in a not yet predictable way throughout the network. That's really the challenge here—that the physical interfaces and the logical interfaces aren't in the same place.

FARBER: Nobody said it was going to be easy.

MILLER: Designing publishable interfaces is going to be a nontrivial task, but worth doing—I believe in it. But we should not be thinking that this is going to be an RJ-11 jack and just plug your info appliance into it. It ain't going to happen that way.

SMITH: Part of me wants to agree with the *laissez-faire* approach, yet *laissez-faire* has led to a proliferation of electronic devices that has delayed ISDN in the marketplace. I have lived through that and I have lived through the situation where standards didn't exist, and manufacturers went their own way.

We've had situations where you can't get a Northern Telecom switch to talk to an AT&T switch or, if you do, it only works on a dozen out of 200 services. So, folks, there are major problems with that. When I started in this industry 15 years ago, ISDN was coming right around the corner and the biggest thing that has delayed its availability has been lack of standards and costs.

PRABHAKAR: We've been talking about extremes of behavior in standards. There is something in between. We haven't done it in many areas very well, but we have some ideas. The first is merely paying attention to standards. Usually people shrug and say, well, that's that other stuff. But all of a sudden it matters to what we're trying to accomplish, so paying attention can help.

In addition, we need active testbeds, having a place where people bring their technologies together and learn how to play together. The telecommunications industry has done this and it needs to be extended.

In terms of the government's role, the fact that we have "Standards" in our name at NIST [National Institute of Standards and Technology] often causes people to assume that we are the ones who set all the standards. We're not. The "Standards" in our name refers to measurement standards that we provide.

But government needs to be much more of a catalyst and a convener and a partner to this private process. There are ways to improve the market-driven standards process, deciding the standard and its timing, by creating an environment that allows market forces to bubble and brew. There are lessons to learn from the Internet process, too.

KERKESLAGER: Arati's [Prabhakar's] comments are right on the mark. Anyone who argues the extremes as the proof that you don't need standards or that you should set them immediately is arguing the wrong point. And it's particularly important as technology moves rapidly that the standards process keeps pace with it. There has to be a method to select standards, such as the ATM standard, and find a unique way to come up with a standard quickly, but in an open manner.

The Internet is one example of using standards in the industry, but there are a lot of other cases where it worked well.

SMITH: I participated for a number of years in both ANSI national standards and CCITT (now ITU) standards, and that environment [for regulatory changes] is much better and the industry has taken a much more active role through things like the ATM Forum. So I don't want to make the picture seem so gloomy. However, we learned some painful lessons at a time when telecommunications infrastructure wasn't a national issue, and it's important that we learn from that history.

Global arena

NELSON: Well, we're working now on the global information infrastructure and a huge problem is international standards, which might take 10 or 15 years to develop. Maybe the system is so broken that we need to start anew.

Just within the U.S. government, we have to coordinate the State Department, the Commerce Department, the FCC, and also the Defense Department. We're working on that and we have an information infrastructure task force that has worked very well on the NII issues. We're just getting off the mark on the GII [Global Information Infrastructure] issues. The additional problem, of course, is that there are 150 countries out there to deal with.

OBUCHOWSKI: On the export of U.S. technology and how we organize ourselves, we have two overarching problems. One is that we in the United States don't know whether we agree on one standard. It is very easy for the Europeans to, on a unified basis, promote GSM [Groupe Spéciale Mobile] technology for cellular telephones. That's a European standard, and they love it.

We've got two different strong digital cellular standards, however, and I'm not the one to criticize that. There's a robustness that comes out of that U.S. process. But I can't really slam the U.S. government for not advocating a given standard when our industry can't even agree within itself.

Our policymakers need to understand that strategies to ensure global adoption of one's national standard is a frontline battleground. The secretaries of State and Commerce and the FCC chair have been much more comfortable talking about privatization, etcetera. That's just hot air—I mean, where the industrial fights get fought is here in the trenches of whose technology wins.

NELSON: And we can fight it on several fronts. We can fight it not only under the banner of competitiveness, but also under the banner of open access. There're all sorts of reasons.

KERKESLAGER: Janice [Obuchowski], this is another example where ATM worked well. The ATM Forum had all of our competitors around the world invited in. And so we put aside international competitiveness issues and said: we're going to compete on issues other than standards; we'll agree on the standard, then we'll all compete on value added above that.

TENNENHOUSE: I have gotten my hands dirty and participated in the standards process. I have been involved, curiously enough, representing Canada and the United Kingdom.

And I learned something: when you represent a different country and you negotiate with the United States, you're negotiating with 250 million individuals. That's a lot tougher than negotiating with the other 150 countries. But that's our culture. And we can either lament it or use it as a tremendous source of strength.

So the issue here is that our vendors need to be able to compete in the global environment and produce on a world scale. We need to have mechanisms for achieving global engineering standards, but still retain national approaches to the exploitation of the resultant technology and how it improves the quality of life. And what we consider an improvement in the quality of life is different from what other countries do. We want to be sure that, in a sense, we preserve our own approach nationally and allow them to preserve theirs.

ATM is a great example. I'm proud of that as someone who's been involved in ATM for

10 or 11 years now. The standards that are being developed are not rigid. They support a wide variety of transmission media. They're very scalable.

The Internet standards have similar characteristics, but what makes them work is a trade show called Interop, which is the most important innovation in standards that I've seen in the time I've been in this business. The show provides a single time and place where the vendors of Internet equipment demonstrate the interoperability of their products.

Now, how does that facilitate standards? Well, if you're planning a product and at the end of that 18 months have to show up with it at the show, you better start working with all those other companies that you'll have to demonstrate with.

The driver here is not rigid standards and a formal process—it's the knowledge that, do or die, your equipment had better work on the floor at Interop. And that causes people to work together in a way they haven't before. I think it's a tremendous improvement in the way the U.S. industry does business.

Glacial regulation

OBUCHOWSKI: Here's where I'd like to make just one more paean to the regulatory mechanics on the information superhighway. Huge companies, the BellSouths and the AT&Ts of the world, can survive even slow government implementation. But I've seen a lot of companies really suffering because of regulatory delays that affect time-to-market. If you come up with a new radio-based technology and it takes five years to license the service, or if you are one of several companies that have developed a video dial-tone technology, and the FCC has yet to act on a 214 market trial, you lose your technology edge.

Fujitsu has copycatted interactive broadband technologies while the FCC has worried about these regulatory issues. So if you look at that sort of three-legged stool of government, industry, and academia, we ought to move on just the housekeeping.

TENNENHOUSE: You have to reduce the barriers.

MILLER: In a standards-driven environment, the only advantage your company has is time.

OBUCHOWSKI: Right.

MILLER: And in the future we're going to have more standards, not fewer. There may still be some compensation, understand, but you're not going to build a business on the royalty stream from some interface standard. You'll have an edge in the market maybe because it will cost you less than the other guy.

The real advantage that you've got, and it's the advantage that this country has culturally, is we know how to move quicker. So what can the government do to help us? Get out of the way.

NELSON: That's why we're re-inventing government.

KERKESLAGER: You said large corporations like Bell South and AT&T can stand a regulatory delay.

OBUCHOWSKI: I just said survive. I didn't mean to imply that it's good for you guys, either. I've seen entities hanging on by their fingernails.

The White House's Mike Nelson [right] discusses the Clinton's administration's policy on telecommunications with other participants, including [left to right] Arati Prabhakar, Woody Kerkeslager, and Matthew Miller.

MILLER: It's the difference between being crippled and being dead.

OBUCHOWSKI: Right.

KERKESLAGER: It is not a difference between being crippled and dead. It's a fundamental paradigm change for government. Large corporations are serving business customers who demand that they get their new services and their new technology on very short cycles, and any unnecessary government delay is absolutely death to corporations in America and to the competitiveness of America.

I believe that this Administration wants to move quickly, to the advantage of the businesses of the United States. But there is sometimes a difference between the policy of the Administration and the paradigms of Federal and state bureaucrats who are implementing the laws and regulations. And that is death to jobs and corporations in America.

TENNENHOUSE: Delays can go against companies, but they can also help. With HDTV [high-definition television], it came down to having good leadership and moving forward at the right time. The delays and the leadership changed the focus of the effort—which is now targeting innovative digital solutions.

Cellular telephony is similar. We could have moved earlier with a relatively naive view of digital cellular based on the earliest standards proposal. However, time has helped shape our understanding of the issues. The competing proponents have learned from each other. I think we'll move ahead with a more mature view of the landscape—with greater scope for innovation.

It's true Europe will have GSM. It looks good today. How is it going to look in 20 years? The United States is going to have a heterogeneous environment. We're going to keep moving from one technology to another.

NELSON: Flexible and minimal regulation is one of the five principles behind our telecommunications policy that the Vice President outlined in January. We couldn't agree more. The United States will not remain dominant if government moves on a monthly or yearly time scale while the technology is changing on a weekly or even daily one. ◆

Industrial R&D: the new priorities

Less time, less money, and a shorter leash are squeezing those engaged in commercial R&D and leaving precious little time for basic science

Bellcore

Personal communications services (PCS) will be the next wave in telecommunications. Customers will be able to call and be called on portable handsets through personal numbers linked to their persons, not a geographical location. Here Bellcore researcher Nelson Sollenberger is studying a prototype system with a view to eliminating interference with the signal.

The four years since the end of the Cold War have witnessed a dramatic revamping of research and development in industrialized countries. The decline in defense spending, the recent worldwide recession, a fiercer global marketplace, and in the United States, the budget deficit—all are changing the goals of research and development and the way in which it is being done. Many kinds of research institutions have been affected. What follows concerns the new outlook of industrial research laboratories. Future articles will focus on consortia and alliances, the establishment of more laboratories by businesses in countries other than their own, university research, and the post–Cold War role of government research institutions.

Lean times have come to research and development. Nowhere is high-technology R&D spending growing as fast as before; and in some countries and technology sectors, the amount of funding itself is going down. Everywhere competition in the marketplace is heating up: company executives are no longer willing to wait 10 years for discoveries to slouch to market but are calling on all hands to help them gain a marketing edge. Scientists and engineers in industrial R&D laboratories are finding that they must do more with fewer resources and do it faster. To a worrying degree, basic long-term research may be getting lost in the shuffle.

R&D is being squeezed by a combination of forces. The global recession that began in the first part of this decade has precipitated a widespread restructuring and downsizing of many businesses and their attendant laboratories. The collapse of the USSR has had effects beyond its borders, especially in the United States and Germany. Roughly half of U.S. spending on R&D comes from the government, and about 60 percent of that has been related to defense. Germany's reunification is sapping its energies and resources and has seriously stressed its economy.

Linda Geppert Associate Editor

These factors are mirrored in R&D employment trends in the three leading industrial nations. In the United States and Germany, the number of scientists and engineers employed full-time in R&D climbed steeply in the 1970s and '80s but has changed little since 1988 [Fig. 1]. In Japan, electronics companies are cutting their R&D budgets and restructuring research management to make it more productive and cost-effective, according to a report by David Swinbanks in this year's first issue of *Research Technology Management* magazine, published by the Industrial Research Institute Inc. (IRI), in Washington, D.C.

To move from the quantitative to the descriptive, the emphasis these days throughout R&D (and beyond) is on speed—shorter

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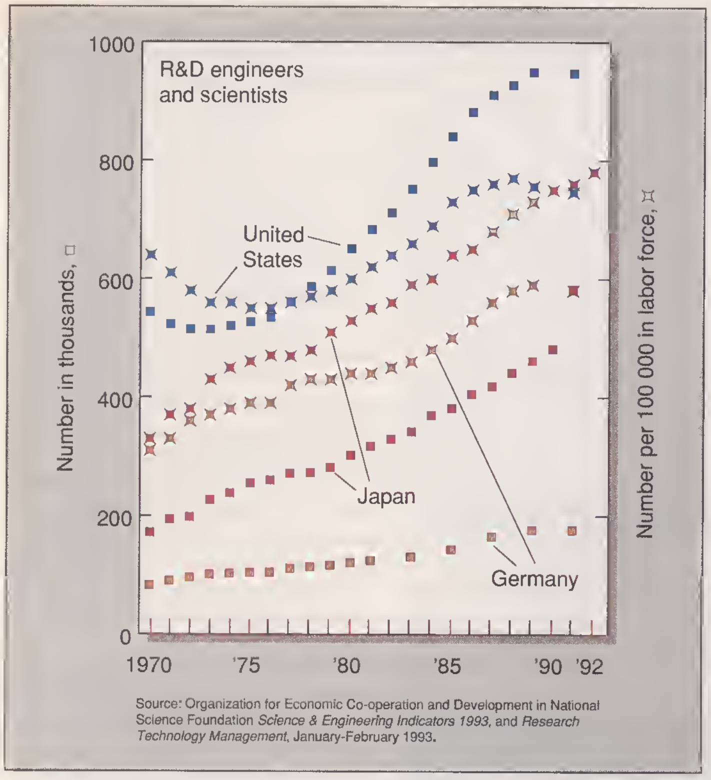
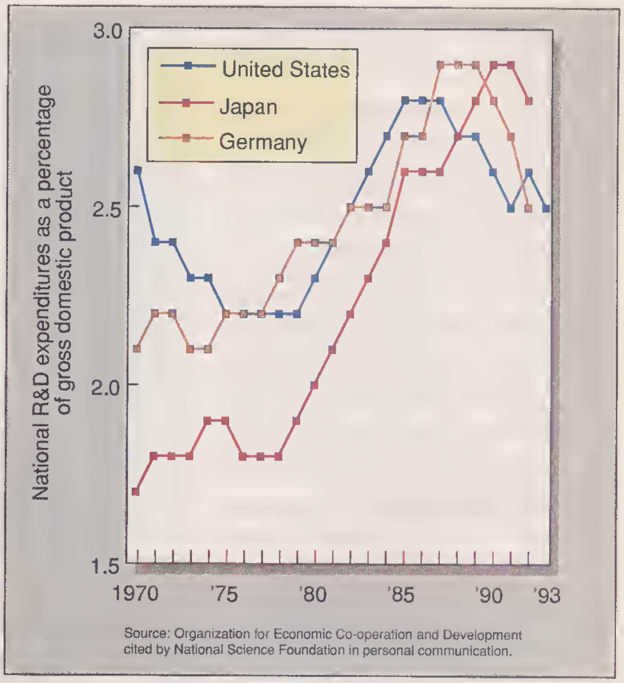


[1] The number of scientists and engineers doing R&D climbed steadily throughout the 1980s. Recent reductions in the United States and Germany reflect the wholesale downsizing within corporations brought about by the recession and fierce competition. Japan's R&D workforce, however, went on expanding through 1992, and, as a percentage of the total workforce, surpassed that of the United States.



[2] This decade has seen a plunge in the fraction of its gross domestic product spent for R&D by each of the three biggest spenders in this area—Japan, the United States, and Germany.

time-to-market, greater reliance on computers, and concurrent engineering—all in the service of greater competitiveness. A few commercial laboratories in the United States warrant further analysis, having been reshaped by regulatory or economic forces within the past decade. For instance, one of the world's premiere commercial research institutions, AT&T Corp.'s Bell Laboratories, was shaken by the company's 1984 divestiture of the Regional Bell Operating Companies (RBOCs)—an effect of a U.S. Department of Justice anti-trust lawsuit against AT&T [*IEEE Spectrum*, November 1985, pp. 41–113, and December 1988, pp. 26–31].

Meanwhile, IBM Corp. barely escaped a similar fate at the hands of the government, though in the end, market forces did what the Justice Department chose not to do; now, far from being a monopoly, the computer company finds competitors behind every tree; and several years of losses have forced it to downsize and refocus its Research Division. The David Sarnoff Center went from in-house research for RCA Corp., to contract research after General Electric Co. bought RCA in 1986 [*Spectrum*, December 1988, pp. 36–39]. Bell Communications Research arose out of the 1984 AT&T divestiture, with thousands of former Bell Labs staff that were to spearhead the R&D requirements of the newly liberated RBOCs. Bellcore, as it is called, is not the first or the last new kind of research institution to sprout these days—a proliferation of alliances, consortia, and research institutes are attempting to supply new technologies demanded by the competitive marketplace. The photo opposite and Figs. 4–8 offer a sampler of current research in industrial laboratories.

PENNYWISE. To begin right at the beginning, funding is basic. The United States, Japan, and Germany invest the most in R&D of all kinds. Still, in each of the three countries, the fraction of its gross domestic product (GDP) being spent on R&D is declining—although that is not the whole story [Fig. 2].

The decline in the fraction of the GDP that the United States invests in R&D has been evident for five years. (In constant 1987 dollars, the absolute amount has barely grown since 1989.) Nor will this trend change in the near future, according to a 1993 survey of its members by IRI. The institute's 260 member companies represent the aerospace, automotive, and chemical, as well as the computer and electronics industries, and embrace 80 percent of U.S. industrial R&D. What the survey found was that 33 percent of the companies (of the 153 that actually responded) planned to decrease R&D spending this year, while only 18 percent planned an increase. The findings in 1991 were almost the reverse: 19 percent planning to lower R&D spending and 24 percent planning to raise it. Overall, the companies expected to reduce R&D spending from 3.49 percent of sales in 1993 to 3.43 percent in 1994.

Some illuminating comparisons among the United States, Japan, and Germany can be drawn from the 1993 edition of *Science and Engineering Indicators*, published by the National Science Foundation, Washington, D.C. In 1991, the latest year that it covers, the United States spent US $123.4 billion (in constant 1987 dollars) on R&D. Meanwhile, Japan spent $60.7 billion, and Germany laid out $29.6 billion (roughly half and a quarter, respectively, of the U.S. outlay). In 1970, the comparable numbers were $16 billion and $13.8 billion, or about one-fifth and one-sixth of the $74 billion U.S. total. (These figures for Japanese and German expenditures were converted into U.S. dollars by means of purchasing power parities, or PPPs, which take into account the different cost in each country of buying a similar basket of goods and services.)

So Japan and Germany are catching up to the United States in actual dollars spent on R&D. And although the fractions of their GDPs that go for R&D are also lower, they now exceed or equal the U.S. fraction.

There are big differences, too, in how government and industry share R&D costs. The 1991 figures from the Organization for Economic Cooperation and Development (OECD), which are the latest available, reveal that in Japan and Germany, most of the money came from industry—72.7 and 60.5 percent, respectively. In Japan, the government supplied only 18.2 percent of the R&D funds; universities and other private sources contributed approximately 9 percent. The German government made up most of the rest of that country's R&D outlay (36.5 percent), with less than 3 percent from other sources. In contrast, only 50.7 percent of U.S. R&D funds came from industry, 46.8 percent was supplied by

the government, and the remainder came from universities and other private sources.

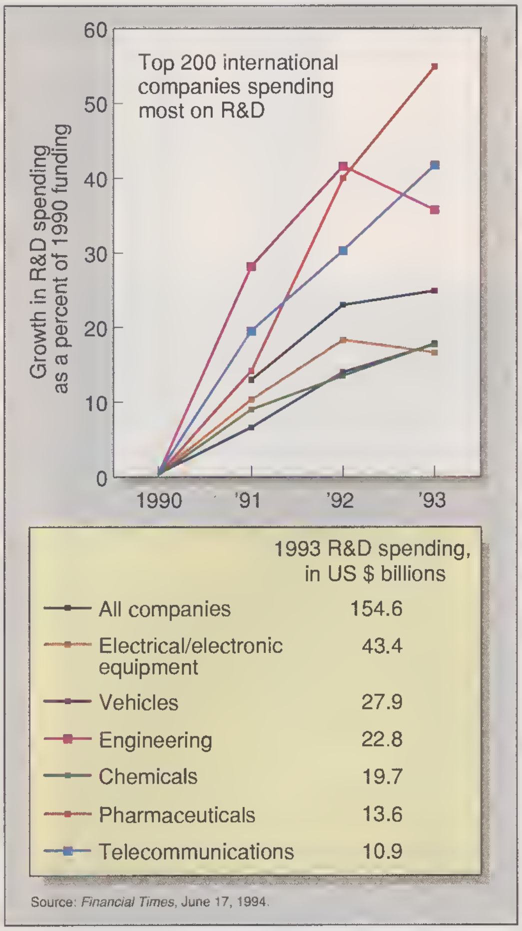
Defense spending, though, absorbed a big chunk of the total R&D funding in the United States—about 25 percent, according to the NSF data, while Japan and Germany spent next to nothing in this area. In terms of nondefense spending alone, their respective outlays were two-thirds and one-third that of the United States in 1991. With the cessation of the Cold War, the fraction the Federal government spends on defense is on the decline, well below 1987's 32 percent. This decrease explains most of the slide in the percentage of its GDP that the United States spends on R&D.

INDUSTRY DIFFERENCES. Within these overall figures, the vitality of R&D varies widely by technology sector. As the IRI's 1993 survey revealed, such industries as pharmaceuticals, personal care products, building products, and food and tobacco products planned to add to R&D expenditures in 1994, but downturns were expected in the electrical and communications sector, in aerospace, and in petroleum and energy-related products industries.

Internationally, the picture seems to be much the same. London's *Financial Times* polled the 200 international companies that were tops in R&D spending (converted from their own currencies to British pounds). The results, published on June 17, 1994, showed that the electronics, electrical equipment, and engineering companies invested less in R&D in 1993, while pharmaceuticals, vehicle engineering, chemicals, and telecommunications spent more [Fig. 3].

As for Japan, the latest NSF data (for 1992) show that R&D spending dropped slightly from 2.9 to 2.8 percent of that country's GDP, while staffing grew at a fairly constant rate. But the following two years were trying for the Japanese economy; and the *Financial Times* report reveals that many major Japanese electronics firms cut their R&D spending in 1993. Reports in Britain's *Nature* and in *Research Technology* magazines reckon the cuts overall at 131 billion yen (US $1.24 billion), and blame the country's continuing recession. Some of these companies are seizing on the cutbacks to reorganize their research institutions for greater responsiveness to their business units' needs. Sony Corp., for one, is asking its labs to obtain more funds directly from the business units and less from the corporation.

"Japan's economy has been in a three-year slump," Yasutsugu Takeda, senior executive managing director of Hitachi Ltd., Tokyo, told *Spectrum*. "Many people say that it will bounce back at the end of this year." But the strength of the yen is a big unknown; and a lot rides on Japan's ability to rein in the skyrocketing appreciation of its currency. So grim was the business climate that Hitachi pruned its 1992 R&D spending by 3 percent in 1993, and Takeda projects another slight dip in 1994. In this regard, he believes that Hitachi is not unique. "The thread of fewer profits and R&D spending cutbacks is common throughout Japanese industry right now," he said.



[3] Trends in R&D spending vary from one technology sector to another. Among the sectors spending most on R&D, those that cut back in 1993 included international electrical and electronic equipment companies and engineering firms, whereas pharmaceutical, chemical, and telecommunications companies beefed up funding. (The amounts spent in 1993 were converted from British pounds to U.S. dollars using the December 1993 exchange rate.)

POSITIONS WANTED. Naturally, with growth in R&D spending stalled, the number of scientists and engineers employed in R&D is not going up either. Companies are relying more on alliances, technological partnerships, and the licensing of technology from other companies.

At Hitachi, 200 fewer scientists and engineers are engaged in R&D this year, down from 13 300 in 1993 to 13 100 in 1994, according to Takeda. He blames the staffing cutbacks on an over-expansion during the early part of this decade—the so-called "bubble economy" period. "We are now trying to restructure and to return to the normal state," he added.

The slippage in R&D employment is also evident at some of the leading commercial research organizations in the United States. For example, AT&T Bell Laboratories emerged from the 1984 divestiture with 16 000 employees [*Spectrum*, November 1985, pp. 97–103]. As Bell Labs filled the void (mainly in systems engineering) created by the 4000 employees who went to Bellcore, and also built up its software engineering competency, employment grew steadily. The number of jobs there has now stabilized at about 27 000, according to its president and chief operating officer, John Mayo, Murray Hill, N.J.

That figure is 2000 under the 29 000 Bell Labs employees reported in *Spectrum* in October 1990 [p. 48]. But while Bell Labs is not adding to its personnel, AT&T's R&D effort overall is still growing through acquisitions and joint ventures, Mayo asserts.

Bellcore, too, supports a smaller staff these days. Employment there peaked in 1990 and 1991 with 8663 workers, of whom 5021 (58 percent) were technical. Now the number has dwindled to 6236, of whom 4182 (67 percent) are technical. "We've become much more cost conscious than we were in 1984," said George Heilmeier, president and chief executive officer (CEO) of Bellcore. "And we have downsized."

In IBM's Research Division, the employment has also tumbled, from 3200 in 1992 to less than 2600 in 1993. In addition, fewer IBM scientists and engineers are doing R&D outside the Research Division, as IBM's worldwide employment continues to drop; and after the dust settles (in three years or so) the corporation will employ about 200 000 people—approximately half of its peak of over 400 000 in the late 1980s. A comparable halving will probably also be seen in the total number of scientists and engineers engaged in R&D throughout the company, according to Trey Smith, director of the physical sciences department of IBM's Research Division, Yorktown Heights, N.Y.

The respondents to the IRI's survey are following a similar course. Ninety percent of them expected that their R&D professional staffing will remain unchanged or slip in 1994. This is bad news for universities that are already struggling to place their science and engineering graduates.

IT'S THE ECONOMY. While downsizing has leveled off the number of scientists and engineers doing R&D, it is the growth in competition that is determining what research gets done. "Everyone has a competitor out there," Heilmeier of Bellcore told *Spectrum*. "It is much easier for companies to enter the marketplace these days, so you have to move quickly."

Once, for example, anyone who wanted to

be in the IC business needed a factory. The only way to get working circuits was to design and build them in-house. But with the advent of design automation and application-specific IC foundries, circuits can easily be designed in one place and fabricated in another. "That lowers the barrier to entry," Heilmeier said. "You don't have to go out and raise $400 million to be in the microelectronics business. If you have some good ideas and some design automation tools, you can get in for a lot less money."

Heilmeier pointed out that there was a time when everyone in the computer industry was vertically integrated. "They started with sand, made their own silicon wafers, and went all the way up to selling computers," he said. "Look at Compaq today. They don't manufacture any components. They assemble components. They can move much more rapidly. They can go out and get the best [parts available]."

Time-to-market is vital above all else to the commercial success of a new technology, John Mayo emphasized to *Spectrum.* The AT&T Bell Labs chief has found concurrent engineering to be a powerful tool. [See *Spectrum,* June 1994, pp. 33–43.] It is simply not competitive to do sequential R&D that progresses from research to development to manufacturing, often with several iterations. "So much more today than 10 years ago, good fundamental and applied research is done right along with the product realization process," he said.

An example of the concurrent approach is the development of the optical amplifier suitable for submarine cable applications. The goal was to replace the electronic amplifiers or regenerative repeaters that are currently used in undersea optical-fiber cables. In contrast to the conventional electronic amplifiers, which can amplify light of one wavelength only, the optical units can amplify all wavelengths of light and several different wavelengths simultaneously. This makes it possible to transmit many pulse-streams concurrently on a single fiber, each on a different wavelength, and all regenerated by the same optical amplifier.

The concept of an optical amplifier was first announced more than 40 years ago, by American Optical Corp., of Southbridge, Mass. Then in 1989, the first laser-pumped, erbium-doped diode was demonstrated by scientists at Japan's NT&T Public Corp. Reacting quickly, AT&T set out to design and build a device suitable for commercial applications. Bell Labs' management accordingly assembled a team of materials scientists, device researchers, systems scientists, developers, and manufacturers to take the concept and make it a reality. The faster pace of R&D today had the team spending only three years on the task, whereas in the 1980s eight years were required to develop the first submarine optical-fiber system.

NEW TOOLS. The evolution of powerful computational and simulation tools has also accelerated the pace of R&D. Research now proceeds more at a run than a walk. Often, simulations of experiments can replace the experiments themselves. Rather than building an apparatus over a period of months to test a hypothesis, simulations can speedily dispose of the blind alleys and wrong turns that are intrinsic to research. Today's laboratory instruments are much more sensitive and versatile as well: measurements can be taken faster and more accurately, then transferred directly to a computer where powerful data visualization tools (themselves an active area of research) aid researchers in their interpretation.

The new tools have also transformed the management of the development process. Engineers sitting at workstations have a tremendous power compared to engineers sitting at their desks 20 or 30 years ago. The powerful computational tools and databases make them more knowledgeable than their managers about the project at hand. In these circumstances, managers can be more effective if they coach and mentor, than if they keep tight control over every step of the project. "This is one reason why the team approach to the development of new products with managers who are coaches and mentors rather than leaders is now more effective than the top-down management style," Mayo pointed out.

AT&T Bell Laboratories

[4] AT&T Bell Laboratories researchers Linn Mollenauer [foreground] and Michael Neubelt experiment with light solitons, pulses that can travel for long distances through specially designed optical fibers without distortion. This feature will speed data transmission by at least a factor of four. In a recent experiment, for instance, solitons were transmitted error-free for more than 20 000 km at a rate of 10 Gb/s, whereas the fastest of today's commercial optical-fiber systems operate at only 2.5 Gb/s.

REDUCTION TO PRACTICE. The focus of industry R&D on time-to-market opens up another gap in the R&D continuum: that of proof of concept, or reduction to practice, according to Larry Sumney, president of Semiconductor Research Corp., Research Triangle Park, N.C. "The job of bringing new technology to market can be divided into three categories—research, reduction-to-practice, and commercialization—and each has its own time scale," he told *Spectrum.*

The basic research on a new technology with commercial potential begins about 10 years before it is brought to market. Commercialization efforts are most intense about three years before the product's commercial readiness, and can be extremely expensive and risky. As an example, Sumney points to sensors for manufacturing processes and systems: "Oftentimes the companies that manufacture the sensors are small; and they bet their life on choosing the right research to commercialize. If they make a mistake, they are probably dead."

During the time period that extends out three to seven years before commercialization, the feasibility of a new product ought to be solidly established. Properly done, this could reduce both the cost and the risk of commercialization, especially for small companies that lack their own R&D facilities. Sumney believes that this is an area where existing resources—particularly consortia and government labs—can be put to good use.

SINK OR SWIM. If research laboratories are more aware of their customers these days, this is especially true for the David Sarnoff Research Center, Princeton, N.J., which must make its way entirely by selling its R&D expertise in electronics—especially digital video, displays, and solid-state science—on the open market. Once the jewel in RCA's crown, it was disinherited in 1986 when General Electric bought its parent and soon after donated the center to the not-for-profit SRI International Corp., in Menlo Park, Calif. The center then reemerged as a for-profit contract research laboratory.

For the first five years of its new existence, the lab was helped by seed money from GE. Even so, 1990 and 1991 were tough years, and the GE funds ran out on March 31, 1992. Now things are looking up. Last year the Sarnoff center turned a profit of several hundred thousand dollars; and today it is adding to its staff to keep up with a backlog of work.

Contract research houses are especially vulnerable to the ups and downs of the economy, according to James E. Carnes, the center's president and chief executive officer. When times are tough, companies stop doing three things, he told *Spectrum.* They stop hiring consultants, they stop doing research, and they stop advertising—and the Sarnoff center is a consultant that does R&D.

A strategy the center is using to buffer it against tough economic periods in the

future is to spin off companies based on technology developed in-house. The strategy not only serves as an additional source of revenue but also supplies built-in customers.

Carnes believes that the center is in a unique position to successfully spin off new enterprises because it can hold on to them until they are strong enough to have a reasonably good chance of succeeding. Then the center can bring in people with the skill and experience to run them. The good R&D people are not necessarily good spinoff starters, he observed. The usual situation is for spinoffs to be started by people who have a good idea while working at one company, then quit their jobs and get some venture capital to start the spinoff. "We think that the ideal thing is that R&D people stay in R&D, and that we bring in people with the skill to start companies. The R&D people are motivated by being given equity in the start-up," Carnes said.

In Carnes' view, the center has a helpful mix of research—60 percent with a near-term orientation for industry and 40 percent for the government, which is willing to support longer-range research. The commercial work, because of its focus on developing new products, helps to keep the center relevant, while the longer-term government contracts make sure that it remains technically vital.

But life as a contract R&D house is a lot different from life as a commercial research laboratory. For one thing, generating revenues takes far more time and energy than in the past. According to Carnes, the center's management personnel find roughly 20–30 percent of their time occupied with bringing in business.

David Sarnoff Research Center

[5] The Princeton Engine, developed at the David Sarnoff Research Center, Princeton, N.J., fuses a magnetic resonance image (MRI) data set and MRI angiography to produce a three-dimensional volume rendering that shows skin, blood vessels, brain matter, and bone in different colors and translucencies. The video imaging technology will be commercialized by a spin-off company later this year.

Today, it is almost impossible—except for vacations and conferences—for a researcher to go five days without being on a recognized project. When Carnes came to the Sarnoff center, in 1969, it was still part of RCA. He recalls that a few months after he arrived he began to work with another researcher on charge-coupled devices. And it took months before Carnes' supervisor acknowledged that the two scientists had joined forces on the project.

Back then, pressures were slight. Even when researchers were on tight schedules, they could take a few hours a week to do side experiments without having to explain why or justify them. They no longer have the float time for such activities; but Carnes believes that they are more vital and effective now than they were before.

A new secrecy is another change at the center, due to the need to maintain the confidentiality of ongoing work, even among other members of the technical staff. When the lab was part of RCA, talking among researchers about their work was encouraged. The center used to hold Friday afternoon seminars that were notorious for the speed and ferocity with which ideas shot up and were shot back down again. But now, the need to maintain the confidence of its customers must be weighed against the benefits of intellectual cross-fertilization.

ALL IN THE FAMILY. Bellcore presents yet a third type of R&D organization: neither a corporate laboratory nor a contract research

The meaning(s) of research

Everyone has an intuitive understanding of what is meant by basic research, applied research, and development. The definitions given, though, are often based not on the work itself but on the motivation of the engineer or scientist doing it.

Basic research conjures up an image of a scientist in a laboratory who studies phenomena purely for the purpose of expanding the knowledge base. The work is not prompted by any interest in solving a practical problem that might augur the creation or improvement of a product. Consequently, some refer to the activity as "pure" research. The implication is that it is uncontaminated by ulterior motives (such as a wish for profits). Two of the numerous other adjectives for basic research are curiosity-driven and investigator-initiated.

The opposite of "pure" research is "applied," rather than impure or dirty. The aim of applied research is to investigate technologies that could be used to create a new product or the next generation of an existing one. Development exploits new technologies to design products that are practical, reliable, and manufacturable.

Some observers offer operational definitions of research. James E. Carnes, head of the David Sarnoff Research Center in Princeton, N.J., pinpoints the difference between basic and applied research thus: getting one thing to work out of 100 versus finding the one thing out of 100 that does not work. (This reporter would argue that basic research is getting one thing to work. Period.)

Mark Bregman, a vice president of IBM Corp., breaks down his company's R&D efforts into four categories: development, advanced technology, exploratory research, and basic research. Development is closest to the product phase, he explained. Upstream of development is advanced technology, in which researchers work closely with the business units, although the work is not yet in the latter group's business plan. Exploratory research investigates alternative technologies. It often goes on independently of the business units, and sometimes even in spite of their wishes.

The fourth category, basic science, Bregman describes as "disconnected" science—disconnected, that is, from IBM's business. "If the scientist has never left the research building and doesn't know the names of IBM's business units, he's probably doing basic science," Bregman joked.

Several commentators have tried to avoid defining research in terms of the researcher's motivation. For instance, "basic research aims to create new knowledge for archives and applications" was proposed by Edward E. Davis Jr., president of EED Inc., Bedminster, N.J., in a 1994 article in *The Bridge* [see To probe further, p.37].

Psychological drives are also absent from the definition put forward by retired IBM vice president John Armstrong. "Basic research leads to new understanding of how nature works and of how its many facets are connected," he said in a Karl Taylor Compton lecture given last October at the Massachusetts Institute of Technology, Cambridge. "Applied research," he added, "aims at making something work."

But research can be contemplated from yet another vantage point, that of whoever is funding it and/or expects to benefit from it. Strategic research is the term widely used to label this perspective. "It is research in scientific areas which are good bets to be helpful in reaching agreed-upon goals of a country or corporation," said Armstrong. Into this category fall several other expressions, such as long-term commercial research and goal-oriented research. In strategic research, the goal is defined first, then the research efforts (both basic and applied) needed to achieve the goal are laid out. Thus it has both basic and applied components.

—L. G.

house. It is most like a consortium, except that, instead of doing only precompetitive research, it in addition supplies real products and services to its seven members, the Regional Bell Operating Companies (RBOCs). Bellcore, and no one else, is responsible for creating and maintaining close to 70 million lines of computer code that essentially run the telecommunications network in this country.

In 1984, the organization sprang full blown from the head of Bell Labs, taking with it 4000 of the labs' former employees. Their job was to focus the research needs of the newly liberated Baby Bells. Initially it bore a strong resemblance to its progenitor. But over the past several years, that likeness has faded. The focus of the research has shifted from the network's physical aspects to its information science aspects. The reason is that the divestiture decree, known as the Modification of Final Judgment or MFJ, prohibits the RBOCs from designing or manufacturing anything. (The MFJ was written by U.S. Federal court judge Harold Green after AT&T and the Justice Department reached an out-of-court settlement of the latter's antitrust case.) "So even if we do good device work, we can't directly benefit from it," explained Heilmeier.

The company has recognized that for its shareholders (the RBOCs) major advances are much more likely to flow from information science. As a result of this reasoning, Bellcore's vigorous program of research in the physical sciences has been whittled down to 50 or 60 researchers, from over 100 four years ago. Some people left to take up positions at universities. Many who stayed are now working on projects that are more closely tied to the near-term goals of the Baby Bells.

Heilmeier is flabbergasted by this aspect of the MFJ. "To have one judge [Green] determine the future of a high-technology industry—one of the foundations of our economy—is the dumbest thing that I can imagine," he told *Spectrum.* "We have to make sure that the electrons and photons that we work with here understand the difference between regulated and unregulated." He hoped for a change in the not-too-distant future.

Research at Bellcore has changed in some other ways as well. The workers are scrutinizing the implications of their work, and the reasons for doing it, much more closely. In the software domain, ongoing work includes reuse, testability, efficient code generation, databases, and a method of creating provably correct code. Also being explored are other avenues to helping the Baby Bells: for example, new sources of revenue, and ways of cutting the operating cost of the U.S. telecommunications system.

And, Heilmeier admits, the short term has come to influence Bellcore's view of R&D. "Let's look at the long-term picture. But let's not lose sight of the fact that we ought to be able to see useful things emerge on a nearer-term basis as well," he said.

The laboratory's working relationship with the RBOCs is evolving, too. Originally, projects had to be agreed to by all the members. Now they more often work on a one-to-one basis with individual shareholders. As at the Sarnoff center, maintaining the confidentiality of the projects constrains the flow of ideas, but is important for maintaining customer confidence.

RED ALERT. While many companies have restructured their R&D organizations in response to economic change, the IBM Research Division's metamorphosis was the most spectacular, and perhaps the most necessary. The company needed all the help it could get in its fight to regain fiscal health. Moreover, with some people questioning the need to have any central research laboratory, the division strove to ensure its own survival by placing itself at the center of IBM's strategic planning activities.

Bellcore

[6] The prototype of an audio and video communication system connects offices, laboratories, meeting rooms, and common areas. Bellcore researchers are using the system to determine what qualities will make it user-friendly.

Mark Bregman, IBM vice president of systems, technology and science, believes that they have succeeded. "We play a very significant role as the hub [of the corporation]," he told *Spectrum.* "And because we are doing exploratory work, and looking out beyond the product lines, we are playing an increasingly important role in helping to formulate the business unit strategies."

Considering IBM's financial difficulties, the slashing of research staff and funding by 20 percent over the past few years is not surprising. And in the context of the draconian measures that have been implemented throughout the rest of the corporation, these cuts seem light. Of more weight are the alterations in the Research Division's relationship with the other divisions and with IBM's customers, and in the basic research that the division supports.

For one thing, development work—which absorbs 25 percent of the Research Division's efforts—is done differently now than in the past, according to Bregman. The percentage has not fluctuated much in the last 10 years; but the way that researchers interact with their counterparts in the divisions, where most of the development work goes on, has changed a lot.

The old model was one of technology transfer—of developing a new technology within the Research Division and then tossing it over the wall to the business units. Now, joint programs between the Research Division and development groups in the other divisions is found to be much more effective. Because both groups agree on a line of R&D, and each contributes funds and staff to the project, scientists in the Research Division do not have to convince developers of the merits of the new technology after the fact. Bregman believes that this type of cooperation helps the division have more impact on the technological direction of the corporation.

The Research Division has also stepped up its direct involvement with IBM's external customers by working with them to solve their knottiest problems—an activity it calls services, applications, and solutions (SAS). It arose a few years back when IBM thought it might become a services company, and the division began to define a role for itself in such an organization. Researchers are now finding that working on such very real problems helps IBM's business and provides fodder for their own fundamental research.

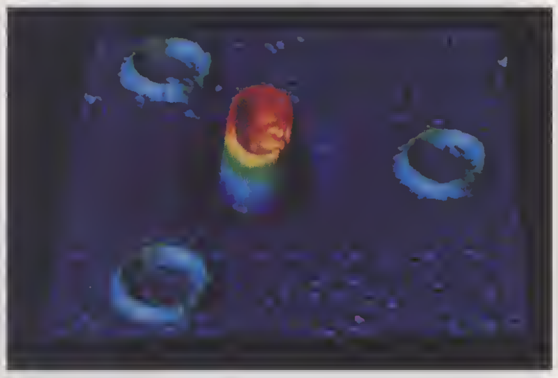
An example is the work that IBM mathematicians did to optimize flight crew schedules for American Airlines. Labor union rules and Federal Aviation Administration regulations require cabin and cockpit crews to be given time off after so many hours on the job. An out-of-town crew will then need transportation, food, and lodging, all paid for by the airline. So the goal is to arrange the schedules so that the greatest possible number of crew members are at home during their time off. The obvious solution—listing all possible combinations of crews and flights and finding the cheapest one that works—would take literally forever to compute for the airline's 2000 plus daily fights. But, by using advanced mathematical techniques, the IBM staff created methods that solved the problem in a reasonable time on a reasonable computer.

Bregman believes that everyone was a winner. American Airlines got a tool to more cost-effectively schedule its flight crews, IBM's business benefited, and researchers furthered their work in optimization theory.

The closer ties the Research Division is establishing with IBM's development groups and its customers indicate an overall philosophical shift toward market-driven research. This philosophy has influenced the

company's approach to basic research as well—a mere 5 percent of the work in the Research Division. Bregman told *Spectrum* that the company wants to continue to support basic science, "but only to the extent that it is world class." With development work, the resulting improvements in the company's products are a benefit to IBM, even if the science involved isn't world class.

"When we do basic science, the value we create is the scientific value. And therefore it has to be world class," he explained. As to what constitutes "world-class" science, Bregman defined it as work that the scientific community recognizes as groundbreaking in its own field or which establishes new fields or new directions of investigation in already existing fields.



IBM Corp.

[7] Yttrium–barium–copper oxide is a superconductor with one of the highest transition temperatures achieved to date. Here, four thin-film rings of the material are imaged by researchers using a scanning superconducting quantum-interference-device (Squid) microscope at IBM's Thomas J. Watson Research Center in Yorktown Heights, N.Y. The image shows that the center ring, which has three grain-boundary Josephson junctions, contains spontaneously generated flux with half the conventional superconducting flux quantum amplitude. Half-integer spontaneously generated flux in three-junction rings is predicted by theory for high T_c superconductors.

Apparently, world-class research can also be identified by the status of those who pursue it. Bregman cited such criteria as being invited to present papers at major international conferences and receiving awards from scientific and professional societies for their work.

Bregman believes that IBM's support of world-class basic science bestows a luster on the company, and also attracts good scientists from the universities who would not otherwise consider joining the company. Moreover, basic research adds spice to the intellectual soup of an industrial lab. Day-to-day contacts between researchers doing basic science and those doing applied work tend to breed innovations.

Basic research at IBM is on safe ground, at least at the world-class level, thanks to support from Research Division and corporate management, according to Trey Smith of the division's physical sciences department. "When Louis Gerstner [IBM Corp.'s chairman of the board and chief executive officer] asks us what are the 10 most important things that research is doing for the company, basic science is on the list."

In line with the new market-driven philosophy, Smith has set about reshaping the agenda of his department—the stronghold of IBM's basic research into physics, chemistry, biology, and materials science. In the first six months of 1993, the number of physical scientists shrank from 300 to a little over 200, and many well-established research programs were discontinued or drastically pruned. Superconductivity now engages 20 people, down from 50 in the mid- to late '80s. The gallium arsenide program has plunged from 100 people studying III-V compounds a few years back, down to 10. Analytical chemistry has been reduced from 20 researchers to five. Polymer science for packaging and lithography applications has half the staff it once did.

At the same time that Research Division management has pared down physical science projects, it is using a number of approaches to build closer ties with customers. One is the Center for Scalable Computing Solutions that opened recently at IBM's Thomas J. Watson Research Center in Yorktown Heights, N.Y. The center will provide marketable scientific and technical solutions for areas as diverse as petroleum and education, as well as for research in computational science

The physical sciences department's foray into numerically intensive computing is not surprising. The tables have turned, Smith explained. Originally the department was connected with the effort to develop new materials and to understand new phenomena that might be exploited in information technology. Now information technology is being exploited to solve physical problems. Imaging technologies are also thriving.

Smith believes that after two grueling years, the bottom has been reached and the Research Division is now on the ascent. It is setting up new laboratories (though in existing buildings) and hiring key people. Moving forward, Smith said, its strategy is to remain grounded in the physical sciences, particularly those that are critical to IBM's business. But every eye will be focused on the market in the struggle to create new business opportunities through their inventions and discoveries, and to interact more closely with customers to solve their physical science problems.

PLANTING THE SEED CORN. Twenty years ago, the great research institutions were popularly viewed as ivory towers where scientists worked in isolation, and whence—every 10 years or so—wonderful discoveries would emerge to change the course of technology. Of these discoveries, the 1947 invention of the transistor, for which Bell Labs scientists Walter Brattain, John Bardeen, and William Shockley shared the 1956 Nobel prize for physics, is often cited as one of the preeminent examples.

Contrary to the popular belief that Bell Labs scientists did a good deal of ivory-tower research, Mayo told *Spectrum* that most of the work done there has always been directed toward solving fundamental problems in telecommunications. Even the invention of the transistor came about in response to the realization that vacuum tubes were too big, too power-hungry, and too unreliable to handle the rapidly growing national telephone network. "A large fraction of our research remains as always to make things work that we need," said Mayo, "and now they include such things as image compression, speech recognition, high-speed fiber optics, and interactive multimedia."

The basic research effort that produced the transistor is still alive and kicking at Bell Labs but it marches to a faster beat. About 10 percent of the labs' total R&D budget supports it—a number that has not fluctuated by more than 1 percent or so over the years. Half the company's 1300 scientists who do basic research are working in teams similar to that of the submarine optical amplifier. The other half, although not working on projects with a market commitment, stay in much closer contact with developers than before.

But the team approach is aimed at realizing specific products and services, not at generating new science and technology, according to Edward E. David Jr., president of EED Inc., Bedminster, N.J. "Teaming shortens lead time, but the emphasis is on incremental, not revolutionary, improvements in products and processes. Corporations are increasingly lean, mean, and stupid—oriented toward results, not understanding of fundamentals," he wrote recently in a National Academy of Engineering publication.

Most observers agree that researchers today—even those engaged in fundamental investigations—are much more closely tied to the commercial goals of their company. Shojiro Asai, general manager of Hitachi's new Advanced Research Laboratory in Hatoyama, Saitama, Japan, wrote in *Advanced Materials* this year [see To probe further] that over the past 75 years, as the electric and electronic industries have become more fiercely competitive, product-cycle times have been reduced, and companies have had to commit their resources to short-term development rather than long-term research.

Still, many observers doubt that doing R&D with one eye on the clock and the other on the bank balance can enhance the likelihood of making a technological breakthrough. George Heilmeier is among them.

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"Long-term research in industry today isn't very long-term," he told *Spectrum.* In his view, the industrial world emerged from World War II with a much broader appreciation of science and technology than it ever had before, and therefore attempted, successfully, to re-create an academic environment in their industrial research institutions. But as the world became more competitive, executives were forced to look at their expenses. "And unfortunately," Heilmeier said, "too many executives look at R&D as an expense, rather than as an investment."

Whereas at one time researchers set a long-term goal and were left alone for 10 years to reach it, the long-term vision, if any exists, must now generate outputs on a yearly basis. "It isn't necessarily that executives are against long-term research," Heilmeier said, "but they want it delivered in one-year chunks. It's when we lose the longer-term vision of why we are doing something—[when] we lose the desire to look at the technologies that might change the business in the future—that I get worried. And that's happening."

In the field of telecommunications, he noted that much of the so-called new technology—fiber optics, digital switching, wireless communications—was developed in the 1960s and '70s. "What really new conceptual breakthroughs in telecommunications have occurred in the last 10 years?" he asked. "Where are the blockbuster ideas that will revolutionize an industry?"

Heilmeier contends that electrotechnology is essentially exploiting in a very sophisticated way ideas that had their origins decades ago. "The free-form type of basic science research that was done in the '50s, '60s, and into the '70s—I don't think that you'll find very much of that today."

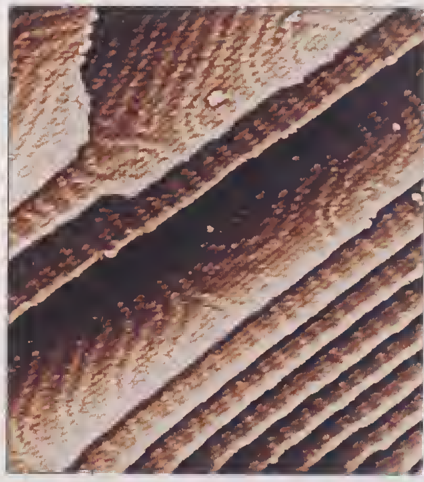
Hitachi's Shojiro Asai expressed a similar view, and added, "We need a replacement for silicon integrated circuits, new ways to handle the overwhelming surge of information, and new clean energy supplies. It is obvious that we need to take a long-term view and assign our most capable people to tackle these issues."

Praveen Chaudhari, research staff member and former vice president for science at IBM's Thomas J. Watson Research Center, believes that as the focus of R&D shifts toward the marketplace, long-term research and exploratory technology are getting less attention. But he thinks that universities can take up some of the load. "I expect basic research and exploratory technology in the [United States] to become more and more the domain of universities," he wrote recently in *Physics Today.* "This will require increased funding for university-based research and stronger ties between university and industrial laboratories." [See To probe further.]

However, James Gibbons, dean of the School of Engineering at Stanford University in California, does not think that it is the job of universities to make up for the dearth of long-term research at commercial laboratories.

"What we do is to educate students," he told *Spectrum.* "The essential technologies to build computers came from commercial laboratories that were supported by companies that were almost monopolistic. And they brought an enormous constancy of purpose and funding that is never true at a university. The fact that there is no long-term commercial research supported by the industry [it will benefit is] a concern that should not be overlooked. And to say that universities can step in and handle that is a pretty big stretch."

Gibbons cites the laser industry, whose gross revenues last year were only about $700 million. "That's not very much," he said. "There's no way for an industry that size, dispersed over many different companies to support the basic research that led to the industry in the first place. That came from Hughes [Aircraft Co.] and Bell Labs."



IBM Corp.

[8] Stepped gold surfaces like these are being used by IBM scientists Phaedon Avouris and In-Whan Lyo at the company's Thomas J. Watson Research Center to study quantum-size effects. The step widths range from 3 to 8 nm. This image was made with a constant-current scanning tunneling microscope. The study of such effects can lead to new insights on the behavior of surfaces that are important in many aspects of IC fabrication.

The latter, he noted, could invent the solid-state amplifier in large part because it had long-term funding from AT&T for the job. The Federal government is not about to provide that kind of support today, nor will any existing industry, he said, observing, "There's nothing in the downsizing and rightsizing of industries that should give any confidence about the degree to which they will support long-term commercial research."

Historically, Bell Laboratories and IBM supported the kinds of long-term research that led to enormous economic return not only for the United States but also for other countries. "Let's just accept the fact," said Gibbons, "that the major technologies [that fueled] development for four decades were invented and developed in laboratories whose purpose and funding has now changed —and that's a cause for worry."

TO PROBE FURTHER. Plenty has been written on AT&T Co.'s breakup. To mention just three books, there is *Disconnecting Parties: Managing the Bell System Break-up: An Inside View* (McGraw-Hill, 1985), in which W. Brooke Tunstall describes the divestiture planning that led to the reorganization of Bell Laboratories and the formation of Bell Communications Research (Bellcore). An excellent account of the drafting of the Modification of Final Judgment is given by Peter Temin with Louis Galambos in *The Fall of the Bell System: A Study in Prices and Politics* (Cambridge University Press, 1987). And lastly, Jeremy Bernstein's *Three Degrees Above Zero: Bell Labs in the Information Age* (Scribner's, 1984) is both sound and entertaining on the history and achievements of Bell Laboratories on the eve of divestiture.

Last year, as it does every two years, the National Science Foundation printed a great deal of information on scientific and technological matters as the 1993 edition of *Science & Engineering Indicators*. The volume is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402; stock number 038-000-00589-8.

As for periodicals, *IEEE Spectrum* surveyed R&D in its October 1990 Special Issue. And Edward E. David Jr. assessed developing trends in R&D in "Science in the Post-Cold War Era" in the spring 1994 issue of *The Bridge* (pp. 3–8), published quarterly by the National Academy of Engineering, 2101 Constitution Avenue, N.W., Washington D.C. 20418. Recent changes in IBM's Research Division were assessed in the June 1993 issue of *Physics Today* (pp. 75–78). In the December issue, Praveen Chaudari presented his views on corporate R&D in the United States (pp. 39–40). A journal more narrowly devoted to industrial research is *Research Technology Management,* published by the Industrial Research Institute, 1550 M. St., N.W., Washington, D.C. 20005.

Hitachi Ltd.'s Advanced Research Laboratory comes under the scrutiny of Shojiro Asai in his "Basic Research in a Japanese Electronics Corporation." The article, which describes the philosophy, research activities, and administrative policies of the laboratory, appeared this year in *Advanced Materials,* Vol. 6, pp. 343–45 (VCH Verlagsgesellschaft mbH, Weinheim, Germany).

The biggest spenders on R&D in U.S. industry are listed every year in the initial June issue of *Inside R&D,* a weekly newsletter. A subscription sells for US $790 ($890 outside the United States); contact Technical Insights Inc., Box 1304, Fort Lee, NJ 07024; 201-568-4744. ◆

Elevators for skyscrapers

Quite a range of technology must go into the design of a modern high-speed elevator to keep the ride fast, safe, quiet, and free of bounce

It's not easy, being a real-estate mogul. Land in big cities like Tokyo and New York is expensive, which is why rentable space is expanded by building high. By and large, though, the taller the building, the greater the fraction of its volume that must be devoted to elevators. Otherwise, the time spent waiting for them becomes unacceptable. In fact, calculations by Mitsubishi Electric Corp., found that almost 30 percent of the total space in a 100-floor skyscraper must be devoted to elevators, including their hoistways, halls, and machine rooms [Fig. 1].

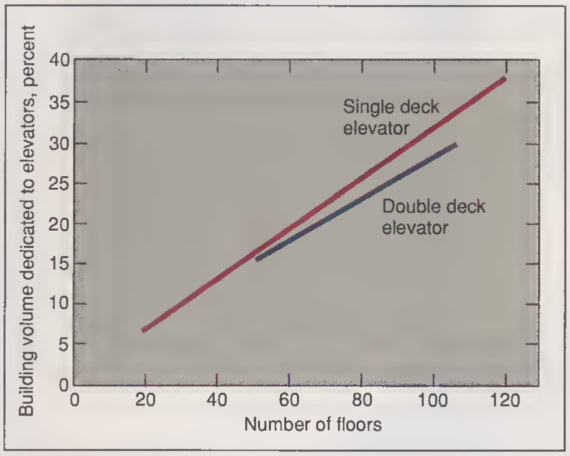
The speed of elevator cars also affects the level of service. Prior to 1993, the world's fastest elevators were the Mitsubishi units installed in the Sunshine 60 building in Tokyo in 1978, which operate at 10 meters per second. More recently, improvements in construction and motor control techniques enabled Mitsubishi to set a new record of 12.5 m/s with the elevators it supplied for the 70-story Landmark Tower. At 296 meters, this is the tallest building ever constructed in Japan [Fig. 2].

Nonetheless, the techniques used to build the Landmark Tower elevator system, despite their success, cannot be extended without limit as buildings get taller. At the present time, proposals exist for building skyscrapers with heights in excess of 1000 meters, or upwards of 200 floors. For such buildings, elevator manufacturers will have to think about brand new technologies—ropeless systems with multiple cars in one shaft form one striking example. But before examining those new technologies, let's review the main technical problems faced by designers of elevators for skyscrapers, and then see how far the conventional answers have been pushed.

Toshiaki Ishii Mitsubishi Electric Corp.

Tall buildings pose problems in seven main areas, some of which are related directly to height, and some of which are consequent upon the need for the cars to run at high speed. The list comprises: vertical oscillation; horizontal swing; safety; buffers (at the bottom of the lift shaft); car noise; ear discomfort; and last but not least, the limitation on cable length.

ROPE TRICKS. Because the ropes—actually steel cables—from which the elevator car hangs are very long, they have rather low spring coefficients. In other words, even quite small disturbances—for example, the torque ripple generated by the traction motor—can set the car to oscillating vertically. The problem becomes acute when the resonance frequency of the cable system lies close to, or coincides with, the frequency of the torque ripple. Under that condition, significant vertical oscillations of the car often result, and the bounce may destabilize the system that controls elevator speed, making car speed very difficult to govern.



[1] The elevator space occupancy ratio in a tall building increases in proportion to building height. Double-deck (two-story) elevators carry more people and, hence, have some effect on the building volume taken up by the elevators.

Unwanted horizontal swing also plagues high-speed elevators. As an elevator car moves through its hoistway, it is guided by vertical rails mounted on the hoistway wall. Contact with the rails is made through roller guideshoes fixed at both the top and bottom of the car. The horizontal swing of the elevator car is caused by curvature of the rails or by inaccurate joining of rail segments. The extent of the swing has been shown experimentally and through measurement to increase in proportion to the car's speed.

Car noise is generated mainly by the car's passage through the air in the hoistway (wind noise) and by the rolling of the guideshoes on the rails (rolling noise) when the car is running at a high speed. The wind noise increases as the sixth power of the speed of the air stream around the car.

All modern elevators have safety devices to back up the cables. These safeties, as they are called, prevent the car from falling if the cable system should fail. They are installed underneath the car and, like brake shoes on a motor vehicle, grasp the rails on either side of the hoistway when triggered by a car speed that exceeds a specified limit. When the safety is activated, its guideshoes must all of a sudden absorb a huge amount of kinetic energy, causing a dramatic rise in their temperature.

Buffers are installed in the pit of the hoistway. They reduce shock to the level mandated by the applicable building code whenever the car or the counterweight strikes the bottom of the shaft. Oil-filled buffers are usual in high-speed elevators. Their orifice must be designed to obtain a legal deceleration factor.

Rapid changes in air pressure occur when the elevator car is accelerated in the skyscraper's hoistway. If the changes come too fast, passengers riding the elevator register them as ear pain or discomfort.

CABLE LIMITS. One of the most interesting technical problems with skyscraper elevators is the height limit imposed by the strength and weight of the cable. The car rise limit can be calculated as a function of five factors: rope strength, rope weight per unit length, car weight, number of ropes, and safety factor. Under the most favorable practical conditions, cable-based elevator systems can be seen to have a car rise limitation of about 1200 meters [Fig. 3].

Note that the figure assumes the use of 10 ropes. Because more than 10 ropes run into difficulties of tension balance, that figure cannot be increased in any practical system. Also, the assumed safety factor of 10 must be regarded as a minimum. Many building codes require higher safety factors, which have the effect of lowering the maximum car rise.

As things turn out, the theoretical limit of about 1200 meters for a total car weight of

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6000 kg (a typical figure) is never reached. In reality, cars cannot rise nearly as far because of other problems, like vertical oscillations.

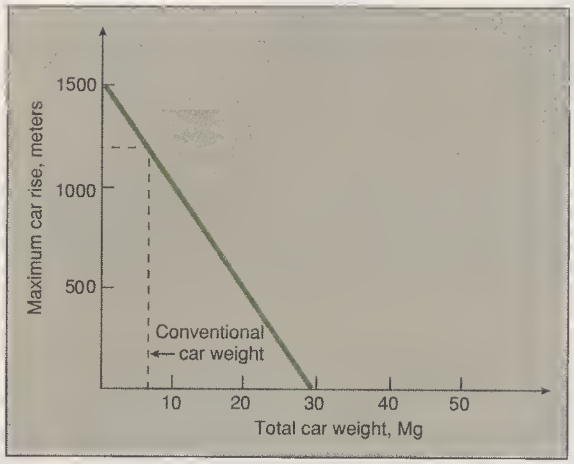
In the distant future, the difficulties associated with long cables will be completely eliminated by the simple expedient of eliminating the cables themselves. In the short term, however, more conservative measures can be taken—as was done, for example, in the Landmark Tower.

LANDMARK TOWER. In that building, the problems associated with high-rise elevators were addressed within the context of a conventional design—one in which the car and the counterweight of the elevator are attached together by ropes through a pulley system. The pulley in that system is a sheave of a traction machine and is driven by an induction motor.

[2] At 296 meters, the 70-story Landmark Tower in Yokohama is the tallest building ever constructed in Japan. Its elevators, which can hit a peak speed of 12.5 m/s, are the fastest in the world.

In Japan, most elevators use variable-voltage, variable-frequency (VVVF) controllers for the drive of the induction motors. In this kind of controller, the ac supply is first converted into dc and then into three-phase ac. Both the voltage and the frequency of the three-phase ac may be modulated to vary the speed of the induction motor in accordance with commands from a controlling microprocessor.

The VVVF controllers in the Landmark Tower system were fabricated with two sets of transistor converters and inverters connected in parallel to supply the required power. This necessitated the modification of the inverter control algorithm to reduce the circulating current that would otherwise flow between the paralleled inverters.



[3] The ability of the cables to support their own weight sets an upper limit on the height a car may rise for cable-based elevator systems. This plot of height versus total car weight is based on the use of common elevator cable with a strength of 320 kN and a linear weight of 2.14 kg/m. It assumes a safety factor of 10 and the use of 10 ropes.

To allow the return of power generated by descending elevators to the power station and to improve the power factor at the ac side of the system, controlled transistor converters are used in place of simple rectifiers. They are set up to keep the dc voltage at a constant value while keeping the power factor at the ac side almost equal to +1 or to −1 (depending on whether the motor is consuming electrical energy or generating it).

To improve the waveform of the ac current, both converters and inverters operate in a pulse width modulation mode, which yields a sinusoidal current waveform. And all the operations of the converters and inverters are controlled by high-performance digital signal processors.

ELEVATOR DEBOUNCING. The system installed in the Landmark Tower attacks vertical oscillation in several ways, most of which involve the use of these high-performance digital signal processors running rather sophisticated control algorithms. One source of torque ripple is attributable to the current transformers used to monitor the instantaneous motor current. These devices tend to introduce an offset error into their outputs, which is then transformed into a dc voltage in the output of the inverters, which in turn is transmitted to the motor, causing a ripple in the torque. Ripple from this source can be greatly reduced by software that compensates for the offset in the measured current value.

Another cause of torque ripple at the motor side is the switching dead time of the transistors. This dead time is normally used to avoid short circuits in the inverter's arms during commutations between the transistors of the upper and lower arms. To compensate for the dead-time effect, a special circuit was designed to feed back the output voltage and calculate the appropriate voltage command.

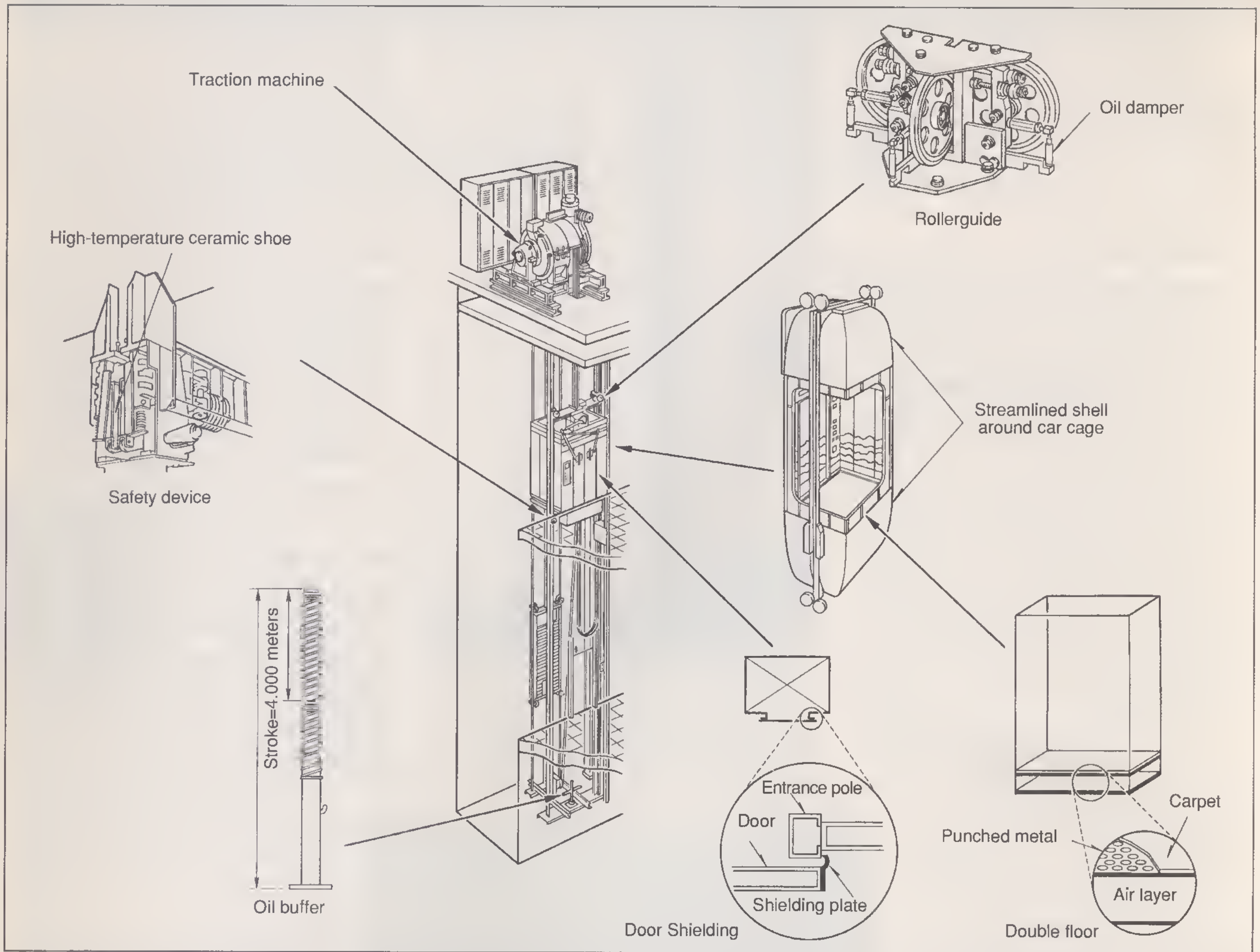
Torque ripple was still further decreased simply by using very fast digital signal processors. These shorten the response time of the control system, thus reducing the current ripple, and hence the torque ripple. Finally, in a type of adaptive control, the gain of the speed-control loop was made to vary as a function of elevator speed, further smoothing the ride. The net effect of all the measures taken together has been to reduce the torque ripple at the motor shaft to about 20 percent of what would be expected in a conventional elevator system. Ripple amplification through the cables is therefore low enough not to annoy the passengers.

BIG SWING. Experiments have shown that the horizontal swing of an elevator car increases proportionally to the speed of the car. If conventional rails and roller guideshoes were used, the horizontal swing of the car would exceed acceptable limits at the Landmark Tower car speed of 12.5 m/s.

In order to damp the horizontal swing, roller guideshoes were developed using an oil damper with a suitable damping coefficient [Fig. 4, upper right]. The design of the new guideshoes was based on computer simulations and the experimental results of vibration tests. Their use decreased horizontal swing by about 20 percent—and simultaneously added to rider comfort. To further smooth the ride, the characteristics of the rails and their joining system were also improved.

The safety devices presented a more fundamental problem. Their operating speed is 15 m/s for a rated speed of 12.5 m/s. But at 15 m/s, according to computer simulation, shoe temperatures would exceed 750°C, which is more than conventional cast iron shoes can withstand. With advanced ceramic technology, fortunately, it was possible to design and develop ceramic shoes that brake steadily and satisfactorily when the surface temperature soars [Fig. 4, upper left].

As mentioned earlier, wind noise increases as the sixth power of the speed of the air stream around the car. At a car speed of 12.5 m/s, it far exceeds every other source of noise—the rolling sound of the roller guideshoes, for example. For that reason, the key step taken to reduce the noise assailing the car was to streamline its shape [Fig. 4, middle right]. To exclude noise as much as possible, the car was constructed with double walls and double floors [Fig. 4, lower far right], while a shielding device was fixed on the back edges of the car door, to bar the entry of outside sounds from the space between the door and the wall of the car [Fig. 4, lower near right].



[4] In building the Landmark Tower elevators, Mitsubishi incorporated a variety of refinements not found in conventional systems. Oil-damped roller guides were added to reduce the horizontal swing of each car by about 20 percent. Ceramic brake shoes were substituted for conventional cast iron units in the safety devices. The shape of the car was streamlined to cut wind and hence wind noise, and it was further noise-proofed with double walls, double flooring, and special sound shielding devices. Finally, the oil-filled buffer at the bottom of the hoistway was designed and built on the basis of extensive computer simulations.

The buffer for the Landmark Tower elevators has a plunger stroke of about 4 meters. Computer simulations were used to design an oil buffer with proper characteristics [Fig. 4, lower left].

Although ear discomfort is not yet troublesome, it will surely become so in future super skyscrapers. In fact, if measures for dealing with it are not found, it may become the limiting factor on elevator speed. Car speeds are unlikely to increase much above present levels until this problem is solved.

MORE CARS, NO ROPE. In Japan, serious consideration is being given to proposals for building skyscrapers with heights of more than 1000 meters. For such buildings, the car rise limit set by rope strength changes from an interesting theoretical point to a truly limiting consideration. Similarly, the elevator space occupancy factor becomes so serious as to make such tall buildings economically unattractive unless some way can be found around it.

The one-shaft, multicar, ropeless elevator system—although by no means ready for deployment—is considered to be the most promising answer to these problems.

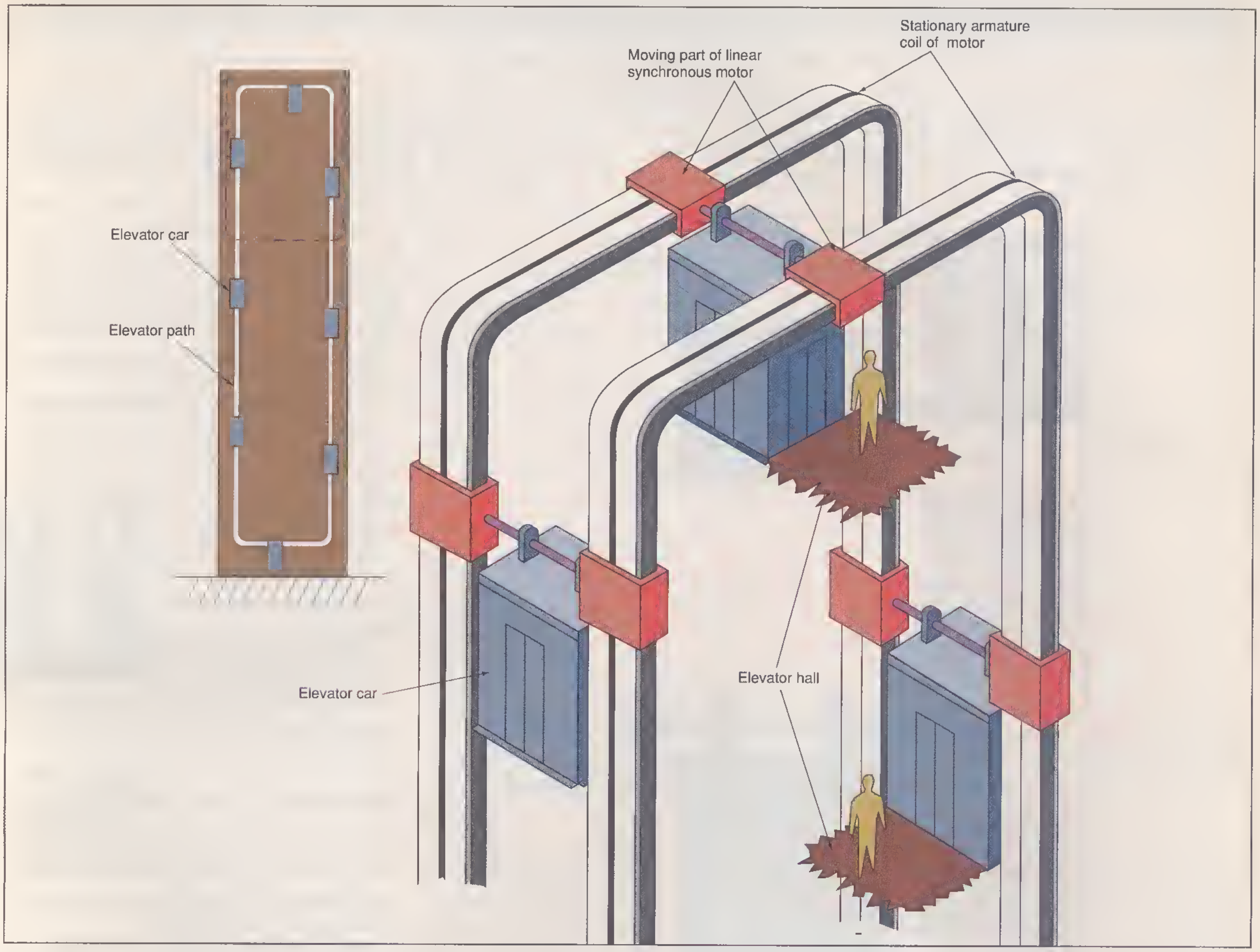
It eliminates the suspension cables, disposing at one go of both the rope-strength and vertical-oscillation problems. In addition, its use of multiple cars in a single hoistway improves the space occupancy factor even in comparison with double-deck systems; and the system can also be shown to im prove transportation efficiency overall in a skyscraper.

One way to build a one-shaft multicar ropeless elevator system is to hang the elevator cab from a bar fixed to the movers of a pair of linear synchronous motors [Fig. 5]. The stationary parts of the motors are a pair of long armature coils mounted along one of the hoistway walls. These armatures can form a loop around the building, extending up one hoistway, horizontally across the top of the building, down another hoistway, and finally crossing the basement to connect with the first hoistway. Because the cab is hung from the linear synchronous motor movers, it always remains vertical, regardless of where it is in the hoistway.

The linear synchronous motors can be fabricated by installing plated permanent magnets on their movers between the armature coils, maintaining a small air gap between the coils and the magnets [Fig. 6]. When the armature coils are excited, the interaction between the excitation flux and the flux of the permanent magnets makes the movers of the motors, and hence the elevator car, move in one direction or another.

Many problems must nevertheless be solved before a ropeless multicar system can be built. One of the biggest involves energy. Roped elevators are usually constructed as pulley systems with counterweights specified to balance the system when the car is loaded to half its rated capacity. Thus, the maximum weight the traction machine has to lift is half of the rated capacity of the elevator.

A ropeless system, in contrast, must lift the entire weight of the car system—including the car cage, the passenger load, and the



[5] An elegant way to circumvent all rope-related problems is simply to eliminate the rope, as envisioned in the one-shaft, multicar, ropeless elevator concept. In addition to obviating such problems as vertical oscillation, the concept disposes of the space occupancy limitation by having several cars share a single hoistway. In this version of such a system, each car hangs from a shaft fixed to the permanent-magnet movers of two linear synchronous motors. The armature coils of the motors are stationary and segmented into blocks so that each of the cars may be controlled separately.

moving parts of the linear synchronous motors. Clearly far more power is needed.

One feature of elevator systems is that, although they operate at high instantaneous power levels, they do not really consume very much net energy. The reason is that the energy they consume in lifting a weight is not dissipated, but rather stored as potential energy. Thus, it may be recovered when the weight descends, provided, of course, that the regeneration is done with all due efficiency.

As Fig. 7 shows, the actual energy consumption of a ropeless elevator system is strongly dependent on two main parameters: car weight and system efficiency. For a total car weight of four times the rated capacity of the elevator and a system efficiency of 80 percent, the loss ratio is about 3.6 (point P_1 in the figure). Halving the car weight also halves the loss ratio to about 1.8 (point P_2). Boosting the system efficiency to 90 percent further reduces the loss ratio to about 0.84 (point P_3). These are noteworthy reductions. In fact, they make it clear that, for ropeless systems to become practical, the most important technical improvements required are reductions in car weight and improvements in overall system efficiency.

MOTOR CONSIOERATIONS. In theory, it has been confirmed that an elevator car with a reasonable weight can be driven against gravity by a linear synchronous motor constructed as shown in Figs. 5 and 6. This approach is well suited for elevator systems for three main reasons.

First, the armature coils of the motor are *not* mounted on the car. It is easier to connect them to the power supply when they are mounted on the hoistway walls than when they are moving with the car. Second, the system costs less, as it is unnecessary to install very expensive permanent magnets all along the hoistway. Third, when there is a loss of power, the system can "apply the brakes" and slow the car's fall simply by short-circuiting the armature windings.

Superconducting magnets might at first look like a good idea for generating strong fields, but upon reflection they turn out to have many shortcomings. For one, the air gap between the armature coil and the superconductor coil will be large because of the thickness of the cryostat that keeps the superconductor below its critical temperature. As a result, it will be difficult to get a sufficiently high flux density in the air gap to move the car.

For another, the weight of the car will be increased by the cryogenic cooling system. This runs counter to the need to minimize car weight. Then, too, a power supply will be needed on the car to feed the cooling sysem. This addition nullifies the advantage of having the armature coils stationary in the hoistway.

Finally, as superconducting magnets have no magnetic core, they tend to have high leakage flux. This flux may disturb the surroundings and, even if it is not excessive, its very presence may bother some people and reduce the technology's acceptability.

Linear induction motors are also not suitable for this application, because of their low efficiency. One reason for that deficiency is that the air gap is increased by the thickness of the secondary conductor (generally a thick and large metallic plate made of aluminum or copper). Because of the wide air gap, sufficient thrust can only be generated if a very high current flows in the secondary conductor. Then the metallic plate may overheat, even to the point of melting.

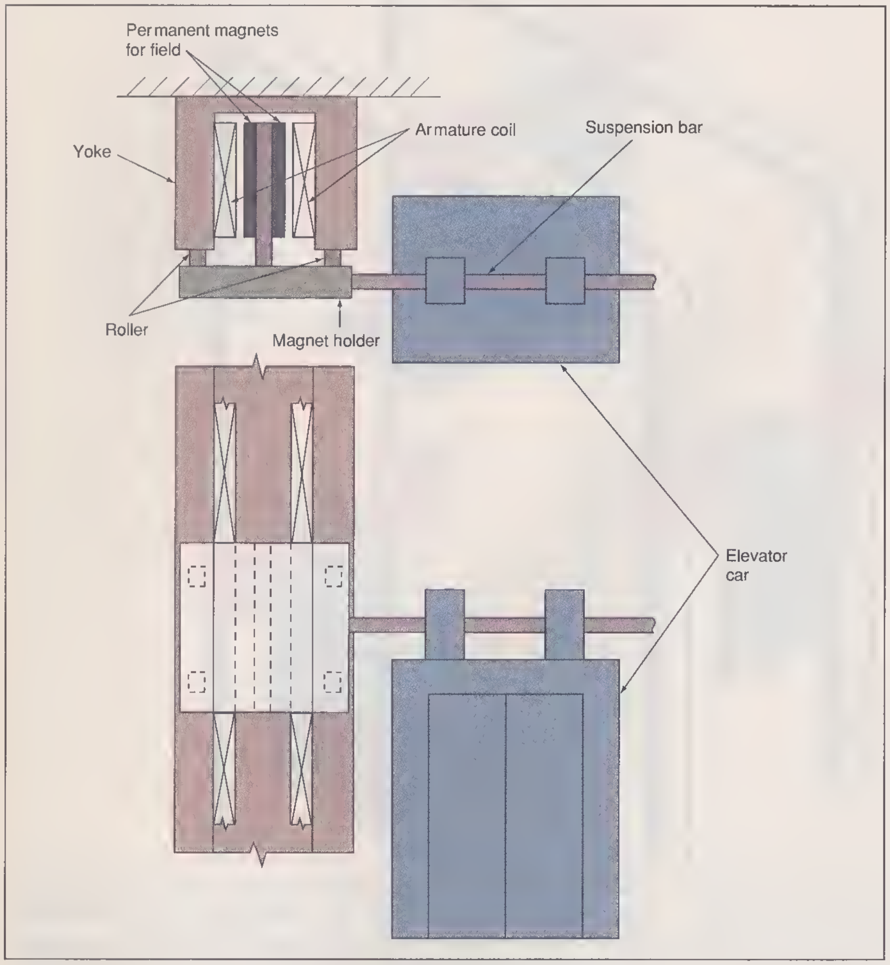
The key to operating multiple cars in a ropeless system is to electrically divide the rows of armature coils into sections, with at least as many sections as there are cars, and with only one car in each section at a time. That way, each car may be controlled independently of the others.

How long the sections should be—that is, how many of them the system should be divided into—will depend mostly on economics. The more sections there are, the more finely the system can be controlled, but also the more expensive it will be to build since each section will require its own high-power switches and inverters.

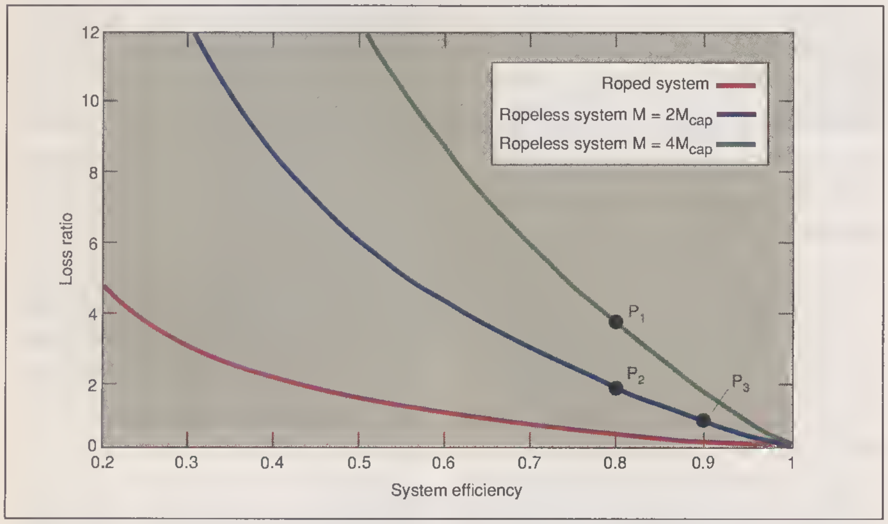
Of course, many other obstacles must be surmounted before such a system becomes practical. For example, means must be devised for circulating the cars and for having them branch and pass one another to improve traffic efficiency.

Safety, too, must get close attention. Not only must the system be made safe, but rescue systems must be devised for trapped passengers in the event of a failure.

Using the Landmark Tower elevators as an example, we have seen the limits to which conventional technology can be pushed to solve the many technical problems of high-speed skyscraper elevators. We have also seen that one way to overcome those limits is the one-shaft, multicar, ropeless elevator, but it is far too expensive to build today. As science and technology advance, however, the costs will undoubtedly come down, and such systems will become economically as well as technically realizable.



[6] The gap between the permanent magnets and the armature coils in a linear synchronous motor can be kept quite narrow, so the motor's efficiency can be quite high. That is its main advantage over a linear induction motor.



[7] The loss ratio—the ratio of energy consumed, or lost, to the potential energy in a regenerative elevator system—is strongly dependent upon both overall system efficiency and total car weight. The heavier the car, the more important efficiency becomes.

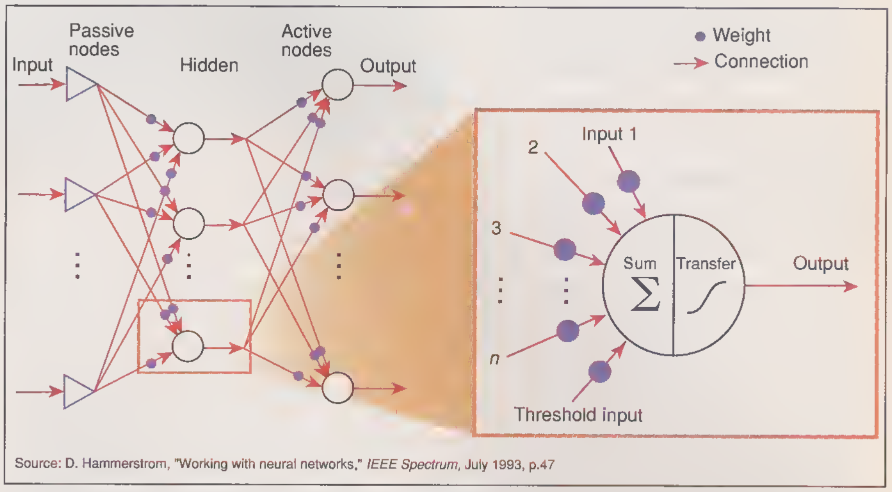
TO PROBE FURTHER. *Elevator Technology 4*, a collection of the presentations made at the 4th International Convention for Elevator Engineering, Elevcon 92, in Amsterdam in May 1992, gives the current status of elevator engineering. The publisher is the International Association of Elevator Engineers; contact George C. Barney, Box 1155, London, NW1 7QG, UK; fax, (44+61) 439 9232. See especially "The Recent Studies on Energy Consumption by Elevator" and "The Best Elevator Rope."

For more on new technologies used in elevator systems, see "New Mechanical Techniques for Super High Speed Elevators" and "New Technology for Elevator Drive Systems" in the April 1994 *Elevator World*; contact Elevator World Inc., 354 Morgan, Box 6507, Loop Branch, Mobile, AL; 205-479-4514; fax, 205-479-7043. Included is a detailed description of the Landmark Tower elevators. ◆

ABOUT THE AUTHOR. Toshiaki Ishii is currently manager of the new products development group at Mitsubishi Electric Corp.'s Inazawa Works in Japan, where his main technical interest has been the development of elevator control systems. He joined Mitsubishi Electric in 1967 after receiving his degree in control engineering from Kyushu Institute of Technology.

Manufacturing ICs the neural way

Neural networks bring unique correlating and generalizing strengths to the hard work of modeling and diagnosing the processes of chip fabrication



[1] A typical neural network using the back-propagation algorithm includes layers of processing or active nodes—one at the output and one hidden layer—as well as a nonprocessing, passive layer at the input. Each active layer computes and filters the weighted sum of its inputs.

The expense of fabricating integrated circuits, already extreme, is becoming unbelievable. By now, only huge companies can take part because a state-of-the-art facility for manufacturing ICs in high volume typically costs several hundred million U.S. dollars. That is over 1000 times as much as it would have cost 20 years ago. If this trend is sustained, facility costs will exceed the total annual revenue of any of today's four leading U.S. semiconductor companies by the turn of the century.

To offset this enormous investment of theirs, chip manufacturers must innovate to a greater degree in the fabrication processes themselves. The aim is to employ the latest computer hardware and software developments—namely, computer-integrated manufacturing of integrated circuits (or IC-CIM)—to optimize the cost-effectiveness of IC manufacture, much as computer-aided design (CAD) revolutionized the economics of circuit design.

Several sub-tasks make up the overall task of lowering manufacturing costs. Chip yields must be increased; product cycle time has to be reduced; consistent levels of product quality and performance must be maintained; and processing equipment must be made more reliable.

The process of making a chip often requires hundreds of steps, each one of which could lead to yield loss. Consequently, maintaining IC quality often entails the strict control of hundreds or even thousands of process variables. The issues of high yield, high quality, and low cycle time are being addressed in part by the development of several IC-CIM capabilities: on-site process monitoring, process and/or equipment modeling, real-time closed-loop process control, and the automated diagnosis of equipment malfunctions. Each of these activities raises throughput and yield by preventing poor processing, but each is complicated both to implement and to deploy.

Gary S. May Georgia Institute of Technology

Recently, neural networks have emerged as a powerful technique for assisting IC-CIM systems with these functions. The networks mimic the behavior of biological neurons, and so share some of the advantages that biological organisms have over standard computational systems. They have in this way succeeded in solving problems that baffled earlier methods.

NET ASSETS. A neural network can perform highly complex mappings on noisy and/or nonlinear data, thereby inferring subtle relationships between sets of input and output parameters. It can in addition generalize from a limited quantity of training data to overall trends in functional relationships.

Although several network architectures and training algorithms are available, the back-propagation type is thus far the most popular in semiconductor manufacture. This algorithm is also a good introduction to the characteristics of neural nets in general.

Feed-forward neural networks trained by back propagation (hereafter referred to as "BP neural networks") consist of several layers of simple processing elements called neurons, interconnections, and weights that are assigned to the interconnections [Fig. 1]. The neurons are interconnected in such a way that information relevant to the I/O mapping is stored in the weights. Each neuron contains

Defining terms

Adaptive control: a system of advanced process control that is capable of automatically adjusting (adapting) itself to meet a desired output despite shifting control objectives and process conditions or unmodeled uncertainties in process dynamics.

Associative memory: a neural network architecture used in pattern recognition applications, in which the network is used to associate data patterns with specific classes or categories it has already learned.

Chemical vapor deposition: a semiconductor fabrication process in which material is deposited on a substrate by means of reactive chemicals in the vapor phase, on occasion at low pressure (well below atmospheric pressure) or plasma-enhanced (in the presence of a plasma discharge).

Factorial designs: designs of experiments in which multiple input variables are varied simultaneously at two or more discrete levels in every possible combination.

Fractional factorial designs: a subclass of factorial designs that reduce the number of experiments to be performed by exploring only a fraction (such as one-half) of the input variable space in a systematic manner.

Response surface methodology: a statistical method in which data from suitably designed experiments is used to construct polynomial response models, the coefficients of which are determined by regression techniques.

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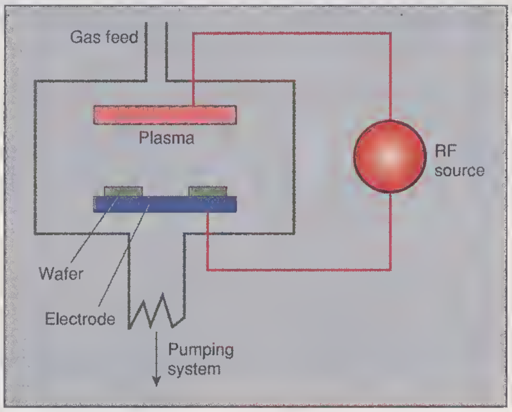
the weighted sum of its inputs filtered by a sigmoid (S-shaped) transfer function. The layers of neurons in the BP networks receive, process, and transmit information on the relationships between the input parameters and corresponding responses. Besides the input and output layers, these networks incorporate one or more "hidden" layers of neurons, which do not interact with the outside world, but assist in performing classification and nonlinear feature extraction tasks on information provided by the input and output layers.

In the BP learning algorithm, the network begins with a random set of weights. An input vector is fed forward through the network, and the output values are calculated using this initial weight set. Next, the calculated output is compared to the measured output data, and the squared difference between this pair of vectors determines the system error. The accumulated error for all of the input-output pairs is defined as the Euclidean distance in the weight space. This Euclidean distance the network attempts to minimize by means of the *gradient descent* approach, in which the network weights are adjusted in the direction of decreasing error. Several authors have demonstrated that if enough hidden neurons are present, a three-layer BP network can encode any arbitrary input-output relationship.

PROCESS MODELING. The ability of neural networks to discover I/O relationships in limited data is useful in semiconductor manufacturing, where highly nonlinear fabrication processes are numerous and experimental data for process modeling is expensive to obtain. Several researchers have of late reported noteworthy successes in using neural networks to model the behavior of a few key fabrication processes.



[2] The plasma etching system simplified here includes an RF source and a gas flow system. The system can be modeled using neural networks.

Each team of investigators has performed a series of statistically designed characterization experiments, and then trained BP neural nets to model the experimental data. The experiments in process characterization typically consist of a factorial or a reduced factorial exploration of the input parameter space, possibly followed and augmented by a more advanced experimental design. Each set of input conditions in the design corresponds to a particular set of measured process responses. This I/O mapping is precisely what the neural network learns.

In an example of this procedure, researchers at the Georgia Institute of Technology, in Atlanta, have used BP neural networks to model ion-assisted plasma etching, a process widely used in semiconductor manufacturing. In plasma etching, patterned layers of material are removed by reactive gases in an AC discharge [Fig. 2]. Because of the popularity of this process, a lot of effort has been spent developing reliable models that relate the response of process outputs (such as etch rate or etch uniformity) to variations in input parameters (such as pressure, RF power, or gas composition). These models are required by semiconductor manufacturers in order to predict etch behavior under an exhaustive set of operating conditions, and with a very high degree of precision. Plasma processing, though, involves highly complex and dynamic interactions between reactive particles in an electric field. Because of this inherent complexity, approaches to plasma etch modeling that preceded the advent of neural networks had met with limited success.

From a fundamental physical standpoint, plasma process modeling is typically accomplished by means of numerical simulation methods that profile the distribution of ions within the plasma but have their drawbacks. The methods are computationally expensive and typically require run times too long for real-time manufacturing applications. Further, the connection between microscopic ion profiles and macroscopic responses like etch uniformity is not yet clearly understood.

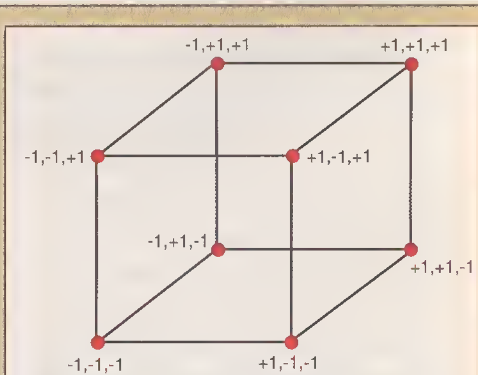
Other modeling efforts have focused on statistical response surface methods [see "Maximizing the return on experiments," below]. Models based on such methods can predict etch behavior under a wide range of operating conditions, but are most efficient when there are only a few process variables—five or less. Plasma etching, however, has many significant variables, and the large number of experiments required to adequately characterize it is costly and usually prohibitive. Consequently, experimenters are forced to choose a reduced set of variables to manipulate, even though plasma etching is a

Maximizing the return on experiments

Experimental design is an organized method for extracting as much information as possible from a limited number of experiments. The approach is employed in areas like agriculture and biology to explore systematically and efficiently the effects of a set of input variables, or factors (like amount of fertilizer), on responses (like crop yield). The unifying feature of statistically designed experiments is that all factors are varied simultaneously, whereas it is traditional to change one variable at a time. A properly designed experiment can minimize the number of times it would have to be run if the traditional approach or random sampling were used.

Two important issues here are choosing the set of factors to be varied in the experiment and specifying the ranges of variation. The number of factors directly impacts the number of experimental runs (and hence the cost of the experiment). The ranges of the process variables are usually divided into minimum, maximum, and "center" levels. In a two-level factorial design, the minimum and maximum levels of each factor (normalized to take on values -1 and +1, respectively) are used together in every possible combination. Thus, a full two-level factorial experiment with n factors requires 2^n experimental runs. The various factor level combinations of a three-factor experiment can be represented pictorially as the vertices of a cube, as shown in the illustration at right.

With a two-level factorial design, however, the number of experimental runs increases exponentially with the number of factors. To alleviate this concern, fractional factorial designs are often constructed by systematically eliminating some of the runs from a full factorial design. For example, a half fractional design with n factors requires only 2^{n-1} runs. Full or fractional two-level factorial designs can be used to estimate the main effects of individual factors as well as the interaction effects between factors. However, they cannot be used to estimate quadratic or higher-order effects. This is accomplished by augmenting the original factorial experiment with higher-order designs, such as the central composite design [see illustration on opposite page]. The supplementary information provided by the axial (or "star") points in the central composite designs enables the quadratic terms to be estimated. The center point provides an extra measure of curvature.



Source: K. Low and S. Director, "An Efficient Methodology for Building Macromodels of IC Fabrication Processes," *IEEE Trans. on CAD*, Vol. 8, 1989, pp. 1299–1313

Once the response of interest has been mea-

highly nonlinear process—a simplification that tends to reduce the accuracy of the response surface method models.

The Georgia Tech researchers compared the response surface method to BP neural networks for modeling the etching of polysilicon films in a CCl_4 plasma. To do so, they characterized the process by varying RF power, chamber pressure, electrode spacing, and gas composition in a partial factorial design, and then trained the neural nets to model the effect of each combination of these inputs on etch rate, uniformity, and selectivity. Afterward, they found that of the two approaches, the neural network models exhibited 40–70 percent better accuracy and required fewer training experiments. Their results further indicated that the generalization capabilities of the neural models were superior to the abilities of their conventional statistical counterparts. This fact was verified by using both the statistical and neural process models to predict previously unobserved experimental data (called test data). Neural networks showed the ability to generalize well even from limited training data.

Likewise, investigators at DuPont Electronics in Wilmington, Del., and AT&T Bell Laboratories in Murray Hill, N.J., have reported positive results using neural nets for plasma etch modeling. The DuPont group also modeled polysilicon etching, and found that BP neural nets consistently produced models exhibiting better fit than second- and third-order polynomial models based on response surface methods. They, too, found that their neural process models generalized test data effectively.

At Bell Laboratories, researchers made use of neural methods to model the etching of tantalum silicide/polysilicon gates in MOS transistors. This group trained neural nets to predict how much silicon dioxide wouldl be left in the transistor source and drain regions after the etch, using data from an actual production machine for the training. They subsequently used their neural etch models to analyze the sensitivity of this etch response to several input parameters, obtaining much useful information for process engineers as a result. They found, for example, that the most significant parameters in the polysilicon portion of the etch process were gas flow and induced dc bias, whereas chamber pressure mattered less.

Other manufacturing processes besides plasma etching have benefited from the neural network approach. To name just one, chemical vapor deposition processes are also nonlinear and also have been modeled by these means to good effect. Researchers at the University of California at Berkeley combined BP neural networks and influence diagrams in order to synthesize a recipe for, as well as to model, the low-pressure chemical vapor deposition of polysilicon. Another Bell Laboratories group (from the Princeton, N.J., facility) demonstrated that neural networks provided appreciably better generalization than regression-based models of silicon chemical vapor deposition. Similarly, the Georgia Tech team has developed neural process models for plasma-enhanced chemical vapor deposition of the silicon dioxide films used as dielectric layers in multichip modules.

PROCESS OPTIMIZATION. A natural extension of the neural modeling of processes is using the models thus obtained to optimize processes or generate recipes for them. The optimization is designed to produce designated target output responses based on the functional relationship between controllable input parameters and process responses supplied by the neural models.

For example, a process engineer may wish to grow, by chemical vapor deposition, a film with zero residual stress or 100 percent uniformity. The neural model can be invaluable for obtaining the combination of process conditions (temperature, pressure, gas composition, and so on) needed to produce the desired result. Essentially, this means using the neural process model "in reverse."

Such process optimization activities have been undertaken by both the Berkeley and Georgia Tech groups with slightly different approaches. The Berkeley researchers have used the generalization capabilities of neural nets (the nets being configured as an associative memory) to generate novel recipes for the low-pressure chemical vapor deposition of polysilicon. At Georgia Tech, on the other hand, current efforts are aimed at using so-called "genetic algorithms" to effectively search the response surface provided by the neural process models. The goal here is to establish a set of process conditions that simultaneously optimizes several responses in a fabrication step for a given application. (Genetic algorithms are guided stochastic search techniques that utilize the basic principles of natural selection to optimize a given objective function.)

Why is process optimization so important? Consider the plasma-enhanced chemical vapor deposition of interlayer dielectrics in multichip modules. The ideal here is to grow a film with the lowest dielectric constant, best uniformity, minimal stress, and lowest impurity concentration possible [Fig. 3]. In practice, these goals usually require a series of tradeoffs in growth conditions. Optimized neural models can help a process engineer navigate the complex response surface to find the best compromise.

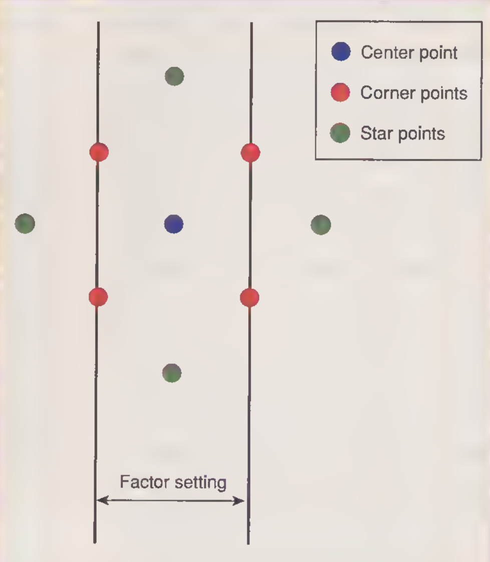
A related task involves optimizing the experimental conditions used to build neural process models. One major but as yet unanswered question concerns how many experiments should be run and in what order when neural nets are being used for semiconductor process modeling. Unlike statistical regression techniques (such as response surface methods), neural-network–based process modeling lacks a sound theoretical basis for designing experiments. Since experimental data on semiconductor processes can be costly to acquire, the number and type of experiments required for proper characterization and the conditions under which this data is obtained are critical concerns.

These issues are being addressed at the Massachusetts Institute of Technology's (MIT's) Microsystems Technology Laboratory and Laboratory for Information and Decision Systems, both in Cambridge. The work is aimed at identifying a general methodology for the use of techniques of optimal experimental design in conjunction with neural network learning. The goal is to determine whether optimal experimental design can establish the process conditions

sured at the various combinations of input factor levels dictated by the design, the results may be summarized in the form of a response surface. A response surface is simply a polynomial fitted to the measured data. The proper fit is obtained by means of statistical regression techniques such as the method of least squares.

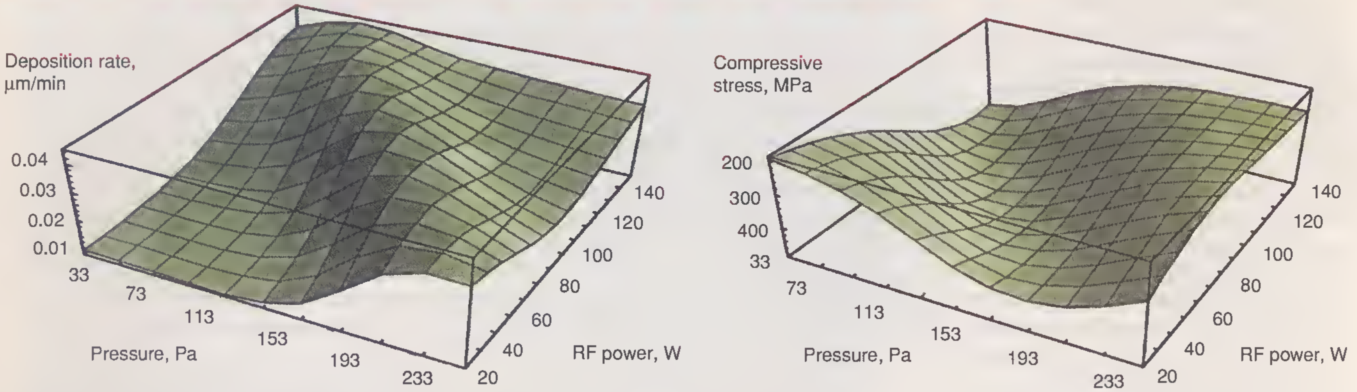
The response surface method is powerful but has some deficiencies. It cannot adequately interpolate functional values between points measured in the experimental design, nor can it extrapolate beyond the experimental design space.

Further, the accuracy of response surface models is limited by the necessarily *a priori* selection of a functional form to which the data must be fit (linear, quadratic, and so forth). Neural networks are advantageous in that they can interpolate and extrapolate with superior generality, and require no prior assumptions about the functional form. —*G.S.M.*



Source: G. May et al. "Statistical Experimental Design in Plasma Etch Modeling," *IEEE Trans. Semi. Mfg.*, Vol. 4, 1991, pp. 83-98

($SiH_4 = 3\times10^8$ mm³/min, $N_2O = 6.5\times10^8$ mm³/min, substrate temperature = 300 °C)



Source: S. Han, *et. al.*, "Modeling the Properties of PECVD Silicon Dioxide Films Using Optimized Back-Propagation Neural Networks," *IEEE Trans. on Components, Packaging, and Mfg. Technology*, Vol. 17, no. 3, June 1994

[3] These response surfaces were generated by the application of neural process modeling to the plasma-enhanced chemical vapor deposition of films of silicon dioxide. One shows deposition rate versus chamber pressure and RF power; the other shows film stress versus the same two factors. These surfaces are typical of those that must be searched effectively in order to locate the optimal growth conditions.

under which experiments should be conducted, thereby defining a data set suitable for subsequent function approximation using neural networks.

PROCESS CONTROL. Since neural networks excel in modeling processes with complex dynamics, they have also been applied to the control of a diversity of such processes, including arc welding, machining operations, lithographic color printing, and even linear accelerator beam positioning. Neural nets are well-suited to process control since they can be used to build predictive models from multivariate sensor data generated by process monitors. So it is no real surprise that control techniques based on neural networks are also appearing in semiconductor manufacturing. In fact, the Kopin Corp., of Taunton, Mass., has used neural network control techniques to more than halve dopant concentration and deposition thickness errors in solar cell manufacturing.

This strategy is also being actively pursued by the Bell Laboratories group in Murray Hill, N.J. They designed a neural network to compute in real time the overetch time for a plasma gate etch step. The network has been learning on line since mid-1993 from many thousands of wafers. After months of close observation, the network has now been officially turned loose for hands-off control on a production etcher. No human intervention is needed any more in determining the proper overetch time. In the opinion of the Bell Labs engineers, in addition to reducing process variation, increasing yield and reducing manufacturing cost, this functional adaptive controller could well extend the useful life of the processing equipment, since design rules continue to shrink and greater performance is constantly being demanded of equipment.

University research groups are also participating in these efforts. The MIT group is focusing on the development and analysis of *in situ* sensing and control methods for the plasma etch process. Its members are currently investigating an approach that combines the compression of real-time optical emission and mass spectroscopy data with neural-network–based fitting algorithms that correlate multivariate sensor data for etch diagnostics and control. The Georgia Tech researchers, on the other hand, are pursuing a control scheme that will operate two back-propagation neural networks in unison: one trained to emulate the process in question, and another trained to learn the inverse dynamics of the process and perform the control operation [Fig. 4]. This structure is advantageous in that it allows both the emulator and controller networks to be trained continuously on-line.

PROCESS DIAGNOSIS. Neural networks have been widely used in process monitoring and diagnosis, mainly in mechanical machining operations such as cutting or injection molding. However, their diagnostic use in the semiconductor manufacturing field is relatively new.

A recently initiated joint venture sponsored by Sematech, Austin, Texas, is examining how to apply *in situ* diagnostic schemes based on neural networks to the plasma etching aspect of IC fabrication. Texas Instruments Inc., in Dallas, is involved along with NeuroDyne, a neural net software firm in Cambridge, Mass., and Lam Research Corp., a vendor of plasma etch equipment located in Fremont, Calif. The goal of the program is to produce a Lam etcher combining data compression and neural-net-based fault detection and identification.

Using neural networks in tandem with expert systems can offset the weaknesses of each diagnostic approach when used alone. Expert systems excel at reasoning from previously viewed data, while neural networks can extrapolate analyses and perform generalized classification when new scenarios arise. This "hybrid" scheme is the strategy being employed by TI/NeuroDyne/Lam and also at Georgia Tech for the automated diagnosis of plasma etch equipment. Hybrid neural expert systems make it easier to acquire and maintain knowledge, as well as allowing implicit knowledge to be extracted (through neural network learning) with the aid of explicit expert rules.

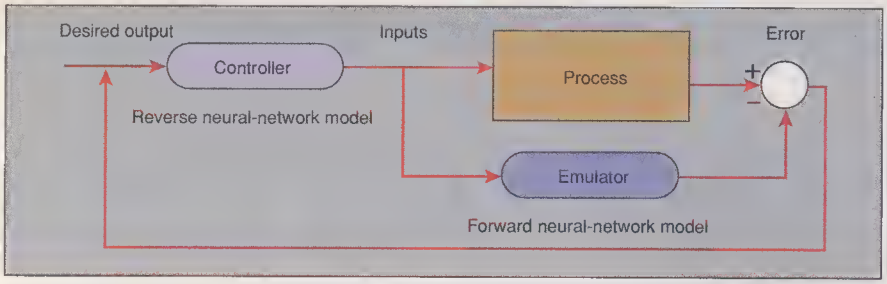
The one perceived flaw in these "neural" expert systems is that, unlike other rule-based systems, the somewhat nonintuitive nature of neural networks can leave the user in the dark as to how diagnostic conclusions are reached. Still, these barriers are lessening as more and more successful systems are demonstrated and become available. In fact, if the above example involving Texas Instruments is any indication, the use of neural nets as a diagnostic tool already seems to be more acceptable to IC manufacturers. Moreover, the MIT researchers believe that the next five years will see neural networks integrated firmly into diagnostic software in newly created fabrication facilities.

In another diagnostic application, the use of BP neural networks for wafer map analysis is being researched at Intel Corp.' s Artificial Intelligence Laboratories in Santa Clara, Calif.

RELATED FIELDS. Neural networks have found uses in fields closely related to semiconductor manufacturing. In the chemical process area, for example, Pavilion Technologies of Austin, Texas, has implemented neural networks, as well as fuzzy logic, in its Process Insights software.

This package, which is designed for chemical manufacturing and control applications, employs historical process data to build predictive models of plant behavior. These models are then used to control process set points and perform optimization. The software has already been used in nearly 200 chemical processing applications in the real world.

Attempts have also been made at the National Semiconductor Corp., Santa Clara,



[4] A novel adaptive process control scheme uses two back-propagation neural networks: a forward network, labeled the emulator, and a reverse network, called the controller.

Neural network applications in semiconductor manufacturing

	Process modeling	Process optimization	Monitoring & control	Process diagnosis	Commercial product
Companies:					
AT&T Corp.	X		X		
DuPont	X				X
Kopin Corp.			X		
Intel Corp.				X	
National Semiconductor Corp.	X				
Pavilion	X		X		X
TI/ND/Lam			X	X	
Universities:					
Georgia Tech	X	X	X	X	
MIT		X	X	X	
University of California at Berkeley	X	X			

Calif., to use back-propagation neural networks to model the current-voltage characteristics of CMOS transistors.

This application, however, requires accuracy over a wide dynamic range of current, and as yet, the researchers at National have found neural network models to be accurate over three decades of variation at the outside. They have also found it hard to determine the best set of learning coefficients and proper learning schedule for this application. Moreover, the standard neural net sigmoid transfer function seems not the best choice for transistor modeling. In spite of these obstacles, the researchers are encouraged by their preliminary results, and they consider the use of neural nets for device modeling to be promising.

GOING COMMERCIAL. The trickle of neural network software applications for process modeling and control is becoming a stream, with Pavilion's Process Insights a prime example. Use of this package is already saving some facilities millions of dollars per year. The Texas Eastman Division of Eastman Kodak Co. has been so impressed that it is encouraging the use of neural networks throughout its plant in Longview, Texas.

In addition, the group at DuPont has developed a PC-based neural net data analysis package called Design Advisor/Neural Analyzer, or DANA. Used for understanding and optimizing physical processes, it guides its users with specifics for designing experiments for subsequent neural network modeling.

DANA was originally implemented to analyze plasma etch data from statistically designed experiments and historical data from photomask manufacturing. Its uses here have led to significant process upgrades. As a result, the analyzer package was recently licensed to NeuralWare Corp. of Pittsburgh for future commercial endeavors.

OUTLOOK BRIGHT. In semiconductor manufacturing, process and equipment reliability directly influence cost, throughput, and yield. Over the next several years, a strong effort in process modeling and control will be required to reach the targets projected for future generations of ICs. Computer-assisted methods will offer a strategic edge in undertaking these tasks, and among such methods, neural networks have certainly proven to be a viable technique. Thus far, they have by no means become routine in semiconductor manufacturing at the process engineering level. Their present use is probably at a point in its evolution comparable to that of statistical experimental design or Taguchi methodology a decade ago—and now statistical methods have become pervasive in the industry.

The outlook for neural networks is therefore similarly promising. New applications are appearing and software is constantly being developed to meet the needs of these applications [see table].

The overall impact of neural-network-based techniques in the field of semiconductor manufacture will depend above all on awareness of their capabilities and limitations, plus a commitment to their implementation. With each successful new application, neural networks gain acceptance, thus making their future very bright indeed.

TO PROBE FURTHER. "Progress in supervised neural networks—What's new since Lippman" is discussed by Don R. Hush and William D. Horne in the *IEEE Signal Processing Magazine*, January 1993, pp. 8–38. The paper has over 150 references. And Richard Lippman's own "An introduction to computing with neural networks" appeared in *IEEE Acoustics, Speech, and Signal Processing Magazine*, April 1987, pp. 4–22.

"Neural networks at work" (June 1993, pp. 26–32) and "Working with neural networks" (July 1993, pp. 46–53) are both presented by Dan Hammerstrom in *IEEE Spectrum*. These articles provide a comprehensive overview of neural network architectures, training algorithms, and applications.

"Neural networks in manufacturing: a survey," coauthored by Samuel H. Huang and Hong-Chao Zhang, appears on pp. 177–186 of the proceedings of the 15th International Electronics Manufacturing Technology Symposium, held in Santa Clara, Calif., October 1993.

"Advantages of plasma etch modeling using neural networks over statistical techniques" are discussed by Christopher D. Himmel and Gary S. May in *IEEE Transactions on Semiconductor Manufacturing*, Vol. 6, no. 2, May 1993, pp. 103–111.

"Neural network control of a plasma gate etch: Early steps in wafer-to-wafer process control," by Edward A. Reitman, S. Patel, and Earl R. Lory, appears on pp. 454–57 of the 1993 proceedings of the 15th International Electronics Manufacturing Technology Symposium already mentioned.

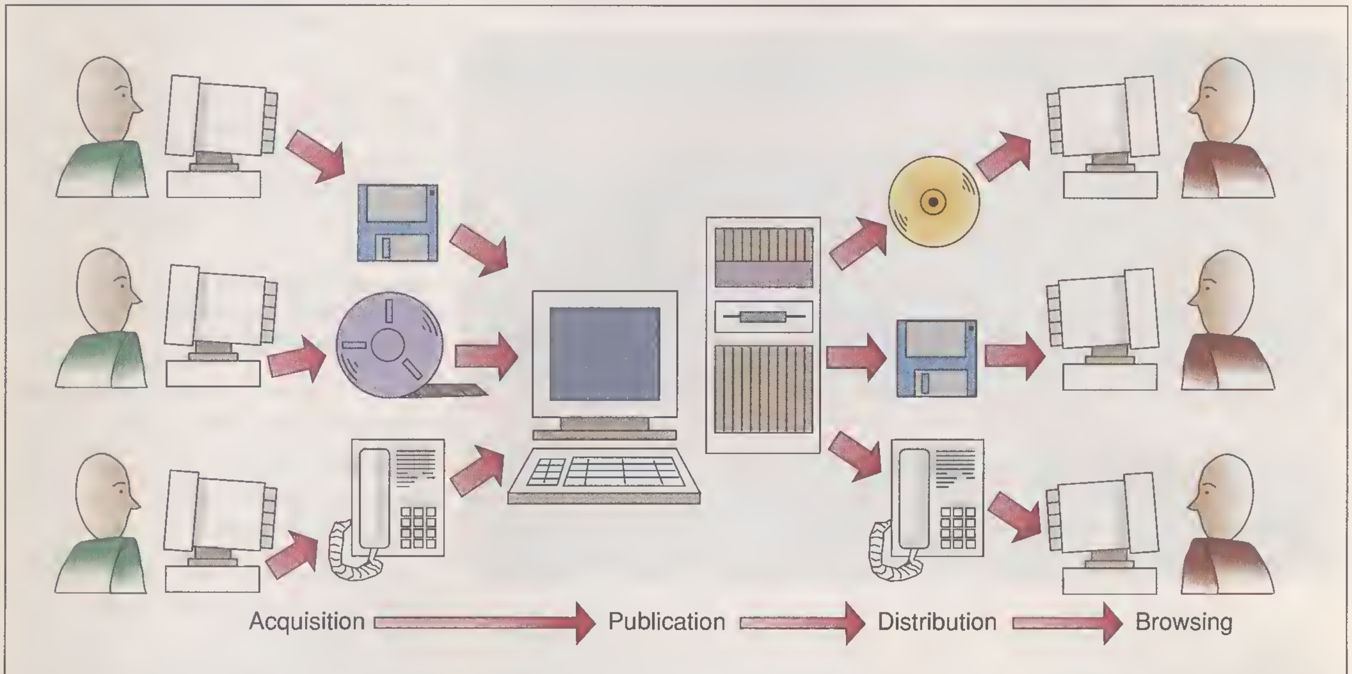
The sixth IEEE International Conference on Tools with Artificial Intelligence will take place Nov. 6–9, 1994, in New Orleans. It will explore artificial neural networks.

Neural networks are regularly covered in publications and meetings of the IEEE Industrial Electronics Society. E-mail contact: p.gold@ieee.org. The *IEEE Transactions on Neural Networks* and the IEEE International Conference on Neural Networks are widely acknowledged as the definitive IEEE publication and conference on the subject. ◆

ABOUT THE AUTHOR. Gary S. May (M) is an assistant professor in the School of Electrical and Computer Engineering and Microelectronics Research Center at the Georgia Institute of Technology in Atlanta. His research is in computer-aided manufacture of integrated circuits, and his interests include semiconductor process and equipment modeling, process simulation and control, and automated process and equipment diagnosis.

Documentation on tap

The cost of preparing, publishing, distributing, and maintaining technical manuals can be cut with a practical approach to electronic documentation



[1] Electronic documentation systems employ the same steps as traditional publishing systems, but with an electronic twist. Electronic documents are acquired in computer format and published by releasing them to a central database. They can then be distributed by floppy disk, CD ROM, or communication link. Such documents can be browsed quickly using a computer.

Editor's note: this is the first of a series of articles on electronic documentation. Future articles in the series will investigate the Standard Generalized Markup Language (SGML) in depth, the state of commercial tools, optical character recognition, and other related topics.

Any company that operates and supports a large installed base of electronic equipment or computer software knows how crucial it is to maintain up-to-date technical manuals. After all, these are the manuals people must refer to when facing tough or unusual problems or when learning to support new products.

Unfortunately, the costs of supplying and maintaining such manuals are high, particularly for large organizations whose facilities are widely distributed. The technical manual for a "central office" telephone switch, for example, may fill up 40 ring-binders. Besides the obvious problems that companies have in reproducing and distributing copies of such weighty documents, they must also tackle the job of keeping them current—duplicating, disseminating, and filing the regular updates made to correct errors, enhance readability, and document product enhancements.

Colin Maunder BT Laboratories

British Telecommunications (BT) PLC, London, England, operates central office and transmission systems from many suppliers. To support the equipment and software for those systems, BT keeps complete copies of technical manuals at over 1000 locations within the company and partial copies at a further 4000 locations. Also supported is a wide range of less complex equipment—from telephones, through fax machines, to private switches—that has been sold or rented to customers.

All told, the manuals for this customer-premises equipment amount to more than 50 000 pages of documentation. In addition, the technical manuals for BT's main network and customer-premises systems are used in conjunction with quality management, health, safety, and other administrative documents that govern the way that employees work.

PAPER MONEY. The total cost of keeping all this documentation up to date is hard to quantify, because the process involves so many separate and somewhat independent elements. Available data, however, suggest that the annual cost is measured in millions of pounds.

The most obvious contributors to this cost include the printing and copying, distribution, filing, and storage of the manuals. Complete copies and incremental updates must be replicated before being distributed—by mail or, for heavier documents, an appropriate alternative carrier.

The costliest task is the filing of updates to large manuals, often in the form of replacement pages. Also, manuals require lots of storage space that is readily accessible to the user community.

Less apparent, but equally important,

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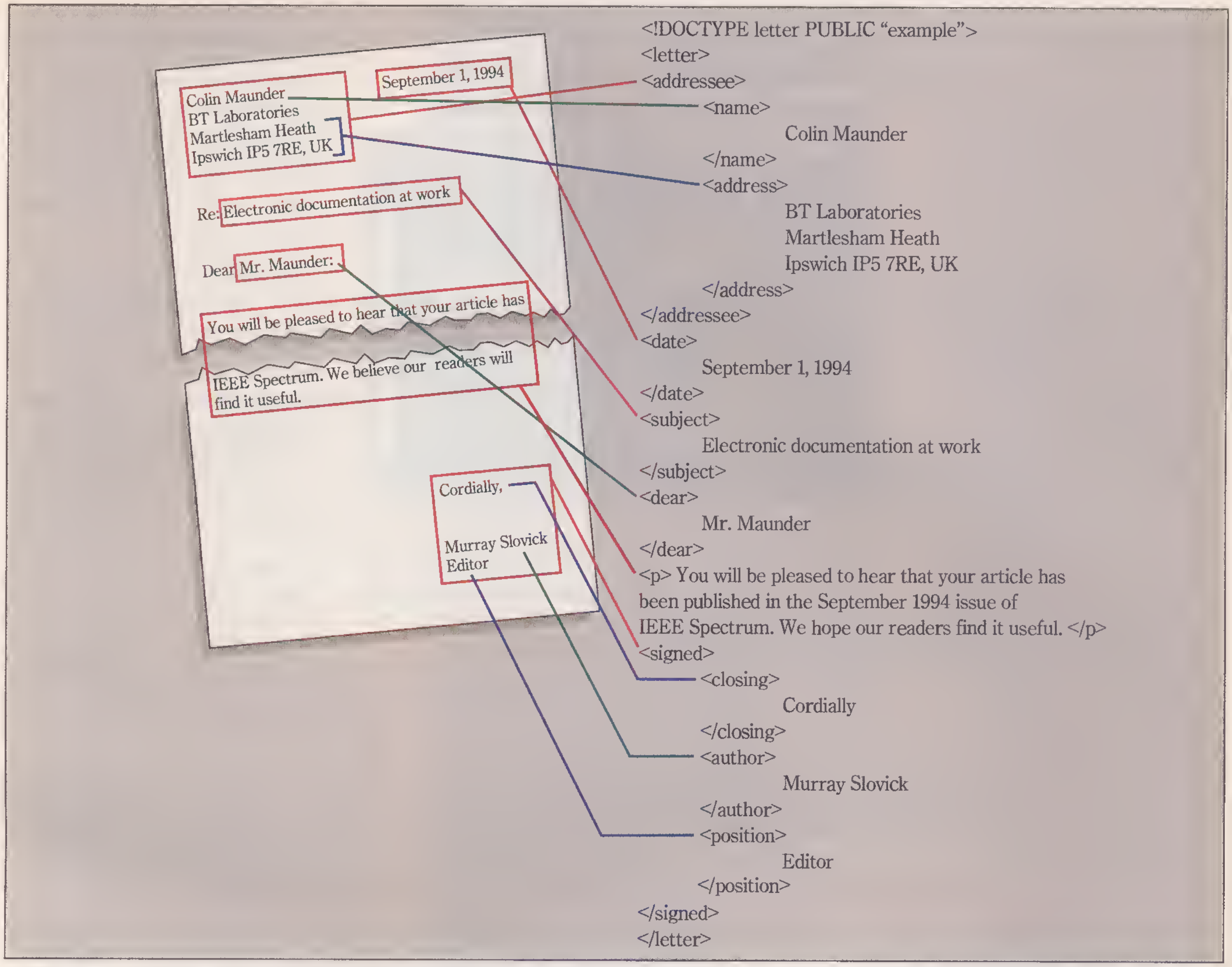


[2] The Standard Generalized Markup Language (SGML) identifies portions of documents so that information may be displayed or printed in a consistent manner. In the file at right, ASCII text has been encoded using SGML; the beginnings and ends of different portions of the text (for a document type called "letter") are clearly identified by SGML descriptors, marked by the characters "<" and ">." The look of the document—its type styles and formating—are defined in a separate file, so changing the look does not require changing the SGML file.

costs arise because of difficulties in accessing information and problems resulting from out-of-date or incorrect information.

Even in the best-written manuals, locating an item of information required to complete a particular task can be difficult. How fast that information can be accessed depends on the size of the document to be searched (the "needle in a haystack" problem), the richness of the document's index, and the proximity of logically related material within the complete manual (for instance, whether related facts are in the same or different volume).

Filing incremental updates to manuals is tedious and can provoke errors. Because the work is often given a low priority, manual users may encounter out-of-date or incorrect information that could mislead them and, perhaps, cause them to make an incorrect diagnosis or other operational errors.

To address these problems—to reduce costs and provide a more effective means of accessing and searching for information—BT is now migrating to the use of computer-based electronic documentation systems with the support of its suppliers, who are increasingly able to provide materials in ways that support the effort. The systems being used can take input from a number of sources and convert it into a common form that can be browsed through, searched, and, where necessary, annotated on screen.

Four key activities are involved: acquisition, publication, distribution, and browsing [Fig. 1].

ACQUIRING THE MATERIAL. Typically, an electronic documentation system must handle both new and "legacy" documents, that is, documents that exist in a form that is not directly compatible with the system; some in fact may be available only in printed form.

New and recently written documents can as a general rule be acquired from their authors in an electronic form—for example, in a proprietary word-processor format such as Microsoft Word or WordPerfect. But older material may have to be retyped or converted into an electronic format through scanning and optical character recognition.

Usually, electronic documentation systems have to handle documents from numerous sources, both internal and external to the company in which the readers of the documents work. So such systems must accept work produced using a range of word- and document-processing tools. (By and large, Murphy's Law applies here: each author will have used a different tool!)

As a result, many implementors have chosen to base their electronic documentation systems on a standard, a vendor-independent documentation interchange language known as Standard Generalized Markup Language (SGML), which has been described in the ISO 8879 standard. Use of SGML [Fig. 2] allows documents to be acquired from many sources while leaving the choice of which tools to use to those who create the elec-

tronic source files, allowing them to follow their personal or organizational preferences.

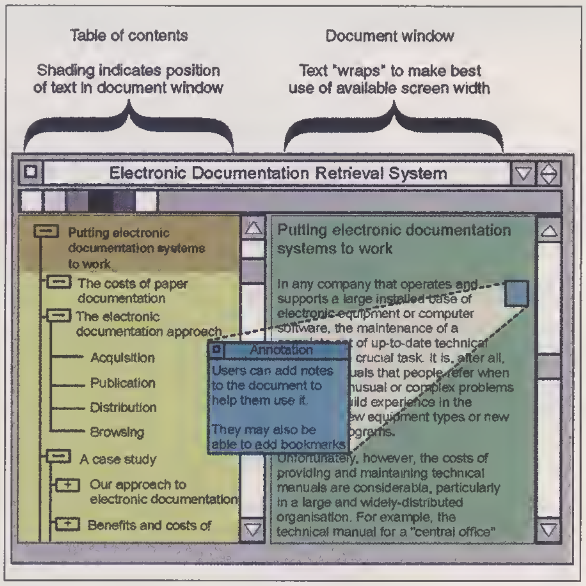
Through SGML, documents can be interchanged between companies or computer systems in a textual form that can be manipulated at the character level by computer software. For example, a user can search for an arbitrary sequence of characters or words.

Another common way of interchanging documents in electronic form is through "bitmap" representations of printed pages, perhaps accompanied by a keyword index to the information contained on each of the pages. This method of interchange—somewhat like an electronic microfiche—allows the document to be read on screen, but results in documentation systems that are less flexible than those based on SGML.

An important feature of SGML is that it encodes the document in a style-independent form. That is, the SGML code identifies the kind (say, chapter title, normal paragraph, or safety alert) and value (the ASCII characters themselves) of a portion of a document. But it does not specify its visual rendition (that is, its style and format—for instance, Bodoni bold 10-point type centered on the line).

The way in which SGML-encoded text is presented, either on screen or on paper, is determined by the publisher, not the author. A related standard—the Document Style Semantics and Specification Language—can be used to move this presentational information between the authoring and publishing systems when it is required that the visual appearance of a document be maintained.

PUBLISHING GAINS. While SGML is an ASCII-text format for interchanging documents, SGML-encoded documents are unlikely to be read directly for two reasons: appearance and direct usability.



[3] Browsing software lets a user search a document for relevant information. In the screen above, the outline of the document at left lets a reader jump to a section by selecting it with a mouse. Adding an electronic note to the text at right is like writing comments in a book's margin.

First, an SGML-encoded document contains only its text and coding that tells what types of information are present. To determine how each type of text should be presented to the reader, further information—in the form of a set of style specifications (one per type of information in the document) collectively referred to as a style sheet—must be supplied. Then the style sheets must be combined with the SGML-encoded data to produce the image that the reader sees, either on screen or on paper. This process is often referred to as "publication."

Second, an advantage of providing documents in electronic form is that it can greatly improve the reader's ability to locate information. Readers now navigate through paper documents by means of such features as the table of contents, the index, and cross references between chapters and sections (such as "see chapter 10"). But, as users of software reference manuals and other large technical publications well know, these navigational aids are of only limited value. Their effectiveness is dependent on the author's ability to second-guess how the reader will want to use the document.

All too frequently, authors provide too few navigational aids—either as a result of their familiarity with the document's content or limits on their time or the document's space. Also, the terms used by the author may not be those with which the reader of the document is familiar, further reducing the utility of an index. Finally, the importance of some of the information may not be recognized at the time of indexing.

Electronic documentation systems can help overcome some of these limitations. For example, tools can be provided to search through the document to find specified text. These vary considerably in their complexity—from being able to search occurrences of a text string, such as the string "electronic documentation" in a document, to being able to locate the word "large" within a specified maximum number of words of "publication."

To make these tools efficient, the document's text must be processed from its source form into a format that allows rapid location of words, phrases, and so on. This process is analogous to that of compiling and linking the source form of a computer program to produce the executable application.

In addition, hypertext may be provided to add functionality to parts of a document, enhancing its value to the reader. Using hypertext, a phrase such as "see chapter 10" could be emphasized in blue type on the screen, indicating that, when readers select this text by pointing and clicking on it with a mouse, they will automatically be taken to chapter 10.

Alternatively, selection of hypertext might reveal the glossary definition of a term, or cause another software program on the computer system to be started (for instance, one that allowed a form in the original document to be filled in and printed).

Any hypertext built into an SGML-encoded version of a document must be processed before it becomes usable, to ensure both the correct visual appearance of the "sensitive" text and the correct functionality when that text is selected. (Hypertext capability is an extension to SGML defined in ISO10744, Hypertext/Time-based Document Structuring Language.)

Converting source SGML-format documents can be costly, especially when "rich" searching and hypertext are to be support-

Pros and cons of electronic documentation distribution methods

Distribution method	Advantages	Limitations
Floppy disk	Readable by most personal computers and workstations; does not require a high-bandwidth network connection	May need many disks to store a large document; slow distribution
Magnetic tape	Can accommodate large manuals	Not widely available
CD ROM	Likely replacement for floppy disks as a software distribution medium, so availability of suitable drives on computers is increasing; can store very large volumes of information on a single compact disk	Slow delivery, due to the need to print CDs and mail to users
Communications network	Fast and reliable distribution (no lost copies)	Islands of high-throughput connectivity may be separated by slow-speed gaps or missing connections

ed in the browsing tool. Therefore, publication is a task that frequently is best performed centrally, before distribution of the "compiled" form of the document.

Electronic documents can be distributed to readers by mailing physical storage media (such as magnetic tapes, floppy disks, or CD ROM) or by transmitting the requisite files over a communications link (such as a private local- or wide-area network or a public "dial-up" line). Each method of distribution has its strengths and weaknesses [see table, opposite page].

Once the document arrives at the reader's machine, the various compiled files that comprise an electronic documentation library need to be turned into an on-screen representation through which the reader can browse, using software designed for that purpose.

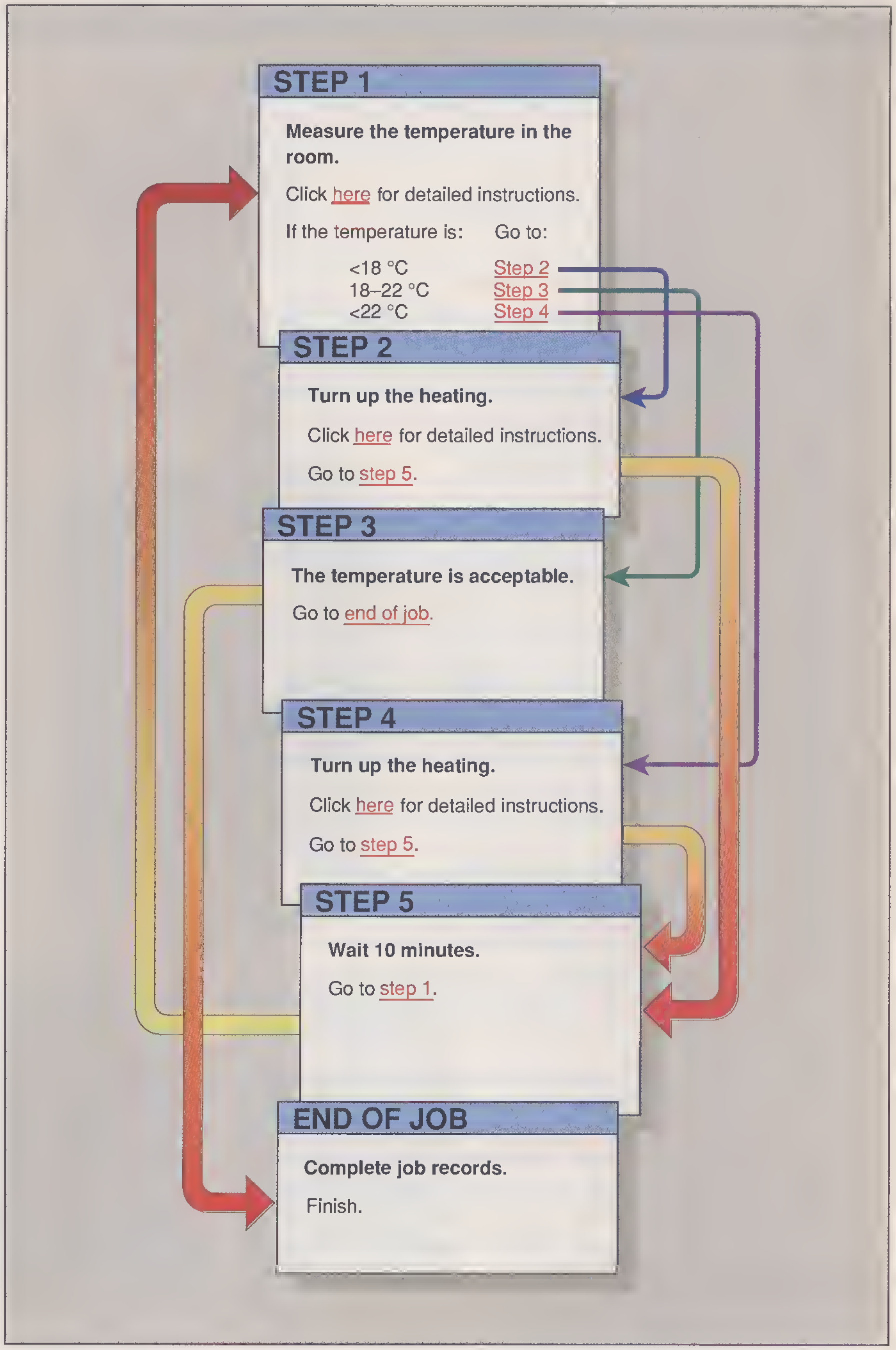
Browser software furnishes a range of facilities to assist readers in locating material of interest [Fig. 3]. Also, some browsers allow readers to annotate their "personal" copies of an electronic document, either with an equivalent of Post-It Notes or with their own hypertext pointers—addressing the issue that "every time I read that page, I find I need to move on to here." (This sort of document personalization is in fact an illusion. All the readers connected to the same local-area network server see the same base document—the annotations they make are held separately, typically for use only by the individual who creates them.)

ELECTRONIC TRANSFER. BT has been working with a number of its principal equipment suppliers to determine the practicality of moving from the paper-based system of supplying and distributing technical manuals to one that is fully electronic.

The company chose to base its electronic documentation system on commercially available tools to take advantage of the products being offered in this rapidly evolving marketplace. BT has therefore focused on three aspects of electronic documentation systems: obtaining documents in a suitable electronic format from their authors (both those within BT and those who work for its suppliers), developing tools to manage "electronic" libraries and assist in document distribution, and (most importantly!) delivering systems to users in a form that they are happy to use.

Rather than ask suppliers to provide their documentation in a particular proprietary format, BT has chosen SGML as the means of interchange. This is attractive both to the company and its suppliers because it enables all those involved to make their own decisions about the tools and processes used in their companies.

For example, suppliers are concerned that, if each of their customers were to ask for electronic documentation in a different format, their costs would escalate. Likewise, BT is concerned that, if its suppliers were to determine the format in which the documentation was supplied, this would impose unnecessary costs—such as the need to train BT employees in the use of a potentially large number of browsing tools.



[4] Hypertext added to SGML documents makes them more useful. In the test procedure above, an instruction to the user is followed first by a hypertext link to details on how to do it [not shown]. Clicking on a step number automatically brings up that step's instruction, thus interactively guiding the operator through the procedure.

By using SGML to move the documentation from one company to another, each of the parties may choose the tools that best suit its business, and few additional restraints are imposed, as is the case with the supply of documents in traditional printed form.

In addition, BT has chosen to leave the editorial responsibility for the technical manuals with the equipment supplier. The goal is to set minimum standards for the acceptability of electronic technical manuals, allowing suppliers to compete on the basis of the value they choose to add. Those who choose to rewrite their manuals may offer hypertext-linked troubleshooting aids [Fig. 4] and other interactive features that help reduce the costs of supporting the documented equipment.

CONVERTING DOCUMENTS. While large technical manuals obtained from suppliers tend to be the focus of electronic documentation

systems, people also require access to company-internal documents like those describing the details of installations, or operational and personnel procedures. Converting these documents to an electronic format presents problems for several reasons.

For one, authors are spread across a company and may have used any of a number of common word-processing tools to write their documents. This means that a number of conversion tools must be developed or acquired.

Another reason is that, while authors may have followed a prescribed visual style guide when producing their hard-copy documents, they will have achieved this style in a near-bewildering number of ways.

One simple, but common, example is the use of the RETURN or ENTER key at the end of each line of text, rather than just at the end of each paragraph. While the visual appearance of the printed document will be the same, the former approach results in a printed paragraph composed of several "software" paragraphs. These will then be handled independently by the electronic documentation system, creating potentially strange visual effects at the browser. The correction of these stylistic differences is a task that can only partially be automated.

Also, a number of documents may no longer be available in any electronic format. For example, as a result of an organizational change, people may have deleted files that were no longer associated with their job. Alternatively, word-processor files may have been rendered unreadable as a result of the rapid changes that occurred in the word-processing and other tools used by authors.

Whatever the problem's cause, the simplest solution is to use scanning and optical-character recognition software to convert the paper version into electronic form. While this process can be automated, it involves a certain amount of manual input—principally to identify the different types of text (headings, lists, and so forth) in the document.

LIBRARIANS AND POSTMEN. Managing an electronic documentation system, just like managing paper documentation, requires a process that ensures people receipt of the documents they require. Three key steps are involved: filing masters, producing copies, and distributing copies to the target audience.

For an electronic documentation system, the management of filed master documents is similar to the task known as software configuration management. Potentially, users may need to access several versions of a document, as happens when a user is operating several installations of the same type of switch, each of which is at a different hardware or software revision level. The master filing system must accommodate this requirement.

In addition, the production and distribution processes require records of the delivery format for each document user (such as magnetic tape, CD ROM, or delivery by file transfer).

BENEFITS AND COSTS. Of the benefits to be achieved through use of electronic documentation systems, the first and most attractive is reduced operational costs.

Electronically "printing," distributing, and filing documents and updates also greatly simplifies the management of documents. BT, for instance, is aiming to distribute documents to user sites automatically through local- and wide-area networks. When this is not possible, documents will be distributed using magnetic or optical storage media (floppy disks or, preferably, CD ROM).

The use of electronic systems also raises productivity. While paper manuals must often be shared, everyone can have his or her own "copy" of an electronic document. This eliminates the need to track down borrowed documents, while sophisticated search facilities increase the speed with which users can find the information they need.

Further productivity gains can be achieved by resorting to hypertext and multimedia. With hypertext, links can be embedded in a document to automatically take users, say, from an unusual term in the document directly to the term's glossary definition, or to a referenced section or figure.

Hypertext links can be used in addition to allow the construction of "automated" procedures in a document, thereby guiding the reader more effectively through a complex task. The inclusion in the document of multimedia enhancements, such as moving pictures (animation or video) and sound, can also help in explaining complex tasks or details.

Also, electronic documentation reduces the cost of failure, that is, it lessens the risk that documents and updates may be incorrectly filed.

And not to be overlooked are the environmental and facility benefits such systems deliver. Obviously, less paper is needed. While this is a big benefit in itself, it is important to remember the space savings that are made by eliminating bookshelves and storage cupboards. (A single CD ROM can hold about the same amount of information as a cupboard full of paper documents.)

The principal disadvantage to be set against these benefits is the cost of converting existing legacy documentation into electronic format. As mentioned previously, this can require manual input and therefore be quite costly. If documents, however, are converted into a standard word-processor "template" format from which conversion into SGML can be automated (rather than directly into SGML from their original form), authors can in effect be "upgraded" from their original word-processing tool to a new common tool and a common document format. This procedure removes the need for further manual input when documents are revised.

In the future, electronic documentation systems may have to be portable. While many people work in buildings where desktop computer systems are readily available, increasing numbers are mobile and are required to work on equipment that is in small, normally unmanned buildings, on customers' premises, or in street-side cabinets. The use of electronic documentation systems built around lightweight portable "notebook" computers could provide this group with rapid access to the information they need. However, current notebook PC products have limited battery life, lack the ruggedness such applications require, and are too heavy.

Despite the challenges faced in creating an easily portable electronic documentation "outlet," electronic documentation systems are already becoming common. Extensive use of such systems is being made worldwide in defense, aerospace, automotive, pharmaceutical, and (of course) computer industries. Thus telecommunications is but one of a growing number of industries employing such systems, and BT's experiences to date, as well as its contacts with other telecommunications companies, indicate that the electronic interchange and use of documentation will also become the norm in this industry by the end of the century.

TO PROBE FURTHER. Of the several books written on the Standard Generalized Markup Language, *SGML, An Author's Guide* by Martin Bryan (Addison Wesley, New York, 1988) provides a good tutorial introduction to the standard. This month, Van Nostrand Reinhold, New York, is publishing *Desktop Magic,* by John M. Wood, which covers all aspects of electronic documentation.

Up-to-date information on electronic documentation systems can be obtained from a number of journals, such as *Electronic Documentation* (Learned Information, Oxford, N.J.) and an increasing number of professional meetings is also being held on the topic. Among the largest is the spring conference of the Association for Information and Image Management (AIIM, 1100 Wayne Ave., Suite 1100, Silver Spring, MD 20910-5603; 3101-587-8202), held annually in the United States.

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ABOUT THE AUTHOR. Colin Maunder (SM) is a technical group leader at BT Laboratories, Martlesham Heath, United Kingdom. He is responsible for the development of advanced tools to support the design, configuration, and support of telecommunications equipment and networks. His interests in test and maintenance engineering have included contributions to the work of several IEEE and ISO standards working groups.

IEEE Awards '94

The IEEE hands out awards for corporate innovation, engineering leadership, service to the Institute, and best papers

Two IEEE awards for 1994, the Corporate Innovation Recognition and the Engineering Leadership Recognition, were presented on June 19 to Bell Communications Research Inc. (Bellcore) and to Clarence Thornton of the U.S. Army Research Laboratory. The ceremony was held at the Sheraton Denver Tech Center Hotel in Colorado.

Clarence G. Thornton
Engineering Leadership Recognition

Bellcore was recognized "for worldwide leadership in broadband fiber-optic telecommunications systems by initiating the concept, establishing detailed specifications, and promoting the development and deployment of synchronous optical networks (Sonet)."

Bellcore, Livingston, N.J., with 7200 employees and annual revenues of US $1.2 billion, is the largest research consortium in the United States. In 1984, when it was set up as the R&D arm of the seven Bell phone companies, the use of optical-fiber systems for broadband telecommunications had just begun, and few products from different manufacturers could work together. To remedy this, Bellcore worked out an integrated network approach and proposed it under the name of Sonet in 1985.

Oscar N. Garcia
Richard M. Emberson Award

Ronald G. Hoelzeman
Haraden Pratt Award

At the heart of the proposal was a flexible digital format for transporting telecommunications services on optical fiber at bit rates that could be chosen to meet demand. The elements of Sonet networks would interconnect through universal interfaces and would also be compatible with the nonoptical equipment already in use.

The first network equipment built to Sonet standards was introduced in 1989, and by the end of 1992 over 20 000 Sonet add-drop multiplexers had been deployed in U.S. point-to-point architectures. Today, Sonet is transforming telecommunications and making broadband, fiber-based systems available to millions of people.

Clarence G. Thornton (LF), directorate executive of the Electronics and Power Sources Directorate at the U.S. Army Research Laboratory, Fort Monmouth, N.J., was recognized "for scientific and managerial leadership in developing military electronic technologies and for his key role in transferring these developments to industry and academia."

Thornton received a Ph.D. in physical chemistry from the University of Michigan in Ann Arbor in 1955. During 1952–55, as a section head at Sylvania Electric Products, he developed semiconductor materials and devices. Then as director of microelectronics R&D at Philco-Ford from 1955 to 1972, he helped to create the first solid-state military radios by designing some of the earliest very high-frequency transistors, and by helping develop the first fully automated transistor production lines, and by discovering the primary destructive breakdown mechanism in power transistors. Subsequent responsibilities included many developments in very large-scale IC technology.

From 1974 to 1993 Thornton directed the U.S. Army Electronics Technology and Devices Laboratory, which developed such things as secure communications, high-resolution radar, smart missiles, and electronic warfare systems. From 1978 he directed an electron devices R&D effort funded at levels above $1 billion, and has served as Army director on major Department of Defense initiatives, including very high-speed ICs, microwave/millimeter-wave monolithic ICs, and rapid prototyping of application-specific signal processors.

Thornton also chaired other efforts, including the Defense, State, and Commerce departments' task group on critical electronic component technology; the Tri-Service Reliance Technology Panel for Electron Devices; and cooperative development and exchange missions to 20 countries.

A Past President of the IEEE Electron Devices Society, he was presented with the Institute's Centennial Medal in 1984. His other awards include the Presidential Rank Award for Distinguished Executive Service (1987) as well as the Crozier Prize for Scientific Contribution to Defense Preparedness (1990).

Service Awards

Two engineers in academia, Oscar N. Garcia and Ronald G. Hoelzeman, who have helped promote the goals of the IEEE and have made outstanding contributions to its work, were honored with the 1994 Service Awards. The presentations were made at the Sheraton Denver Tech Center on June 19.

Oscar N. Garcia (F), professor of electrical engineering and computer science at George Washington University, Washington, D.C., since 1985, received the Richard M. Emberson Award "for outstanding contributions to the technical and educational objectives of the Institute and for leadership within the Computer Society and in technology policy issues."

Garcia was an engineer at IBM Corp. when the company designed its IBM/360 computer. From 1960 to 1970, he taught at the School of Engineering, Old Dominion University, Norfolk, Va., and from 1970 to 1985 he was a professor at the University of South Florida, Tampa, which made him the first chairman of its computer science and engineering department. Currently on leave from George Washington, he is director of the Interactive Systems Program at the National Science Foundation, where he had been program director for engineering in the Education and Human Resources Directorate.

Garcia's early research focused on computer architectures and

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parallel processing, on testing digital circuits, and on arithmetic codes. He developed courses on artificial intelligence and expert systems that are taught in both the United States and Japan.

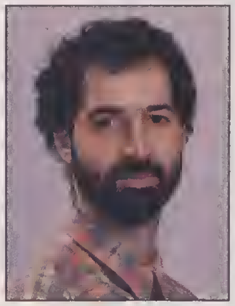
Within the IEEE, Garcia held a variety of posts before becoming President of the Computer Society (1982–83) and serving on the Institute's Board of Directors (1984–85). He created and led the Computer Society's Committee on Public Policy and has been active on the U.S. Activities Board, particularly the Technology Policy Committee, which he chaired from 1989 to 1991, and on the Engineering R&D Committee. He is coauthor of *Knowledge-Based Systems: Fundamentals and Tools* (1991).

Ronald G. Hoelzeman (F), associate chairman of the department of electrical engineering at the University of Pittsburgh, was presented with the Haraden Pratt Award "for continued and outstanding leadership and contributions to many facets of the Institute's operations."

Hoelzeman's engineering career began at Westinghouse Electric Corp., where he designed and installed computer systems for process control and power distribution. In 1970 he joined the University of Pittsburgh, where he developed courses in circuits and linear systems, logic design, and optimization techniques, and helped develop the first model curricula for computer science and engineering. He has also been director of engineering continuing education.

Hoelzeman has been active in IEEE activities for more than 20 years. He has held several executive positions in the Computer Society and he has been IEEE Accreditation Coordinator. As IEEE Vice President–Educational Activities, he promoted a directed approach to the development of continuing education projects, revised program criteria, and initiated a structured planning process.

In addition, Hoelzeman has served in a number of positions on the IEEE Publications Board as well as on Computer Society publications bodies. Among other awards, he has received the IEEE and Eta Kappa Nu Student Teaching Awards, as well as the IEEE Undergraduate Teaching Award.



Michael M. Green
W.R.G. Baker Prize

Andrew P. Sage
Donald G. Fink Prize

Prize Paper Awards

The IEEE Board selected four recipients of Prize Paper Awards.

Michael M. Green (M) and **Alan N. Willson Jr.** (F) share the W.R.G. Baker Prize for "How to identify unstable DC operating points," published in the *IEEE Transactions on Circuits and Systems, Part I: Fundamental Theory and Applications* (Vol. 39, no. 10, October 1992, pp. 820–32).

Green, assistant professor of electrical engineering, State University of New York at Stony Brook, earned his Ph.D. in electrical engineering at the University of California, Los Angeles (UCLA), in 1991. His current research interests include nonlinear circuit theory, analog IC design, and superconducting electronics.

From 1984 to 1987 he was an IC design engineer at National Semiconductor Corp. An associate editor of *IEEE Transactions on Circuits and Systems, Part I* and of the *IEEE Transactions on Education*, Green chairs the Circuits and Systems Society's nonlinear circuits and systems technical committee.

Willson, associate dean of the School of Engineering and Applied Science, UCLA, spent three years back in the early 1960s at IBM Corp., Poughkeepsie, N.Y., taking part in some of the earliest efforts in computer-aided circuit analysis and design. After receiving his Ph.D. at Syracuse University in New York in 1967, he joined the technical staff of Bell Laboratories, Murray Hill, N.J.

Since then, much of Willson's research has concerned nonlinear circuit theory and digital filters. His Baker Prize paper is the most recent in a series of publications providing rigorous qualitative insights into the nonlinear large-signal behavior of transistor circuits, and the theory for the numerical techniques used to analyze them.

In 1973, Willson became an associate professor at UCLA and then a full professor there in 1976. Since 1987, he has also been associate dean of the School of Engineering and Applied Science. His latest investigations have been on the design and implementation of ICs for digital signal processing. Willson, who has more than 50 journal publications to his credit, edited *Nonlinear Networks: Theory and Analysis*, published by the IEEE Press, and has been editor of the *IEEE Transactions on Circuits and Systems* as well as President of the IEEE Circuits and Systems Society. He also received the Guillemin-Cauer Award of the IEEE Circuits and Systems Society (1979) and an earlier W.R.G. Baker Prize (1985).

Alan N. Willson Jr.
W.R.G. Baker Prize

Oliver M. Collins
Browder J. Thompson Memorial Prize

The 1994 Baker Prize was awarded to the two men on May 31 during the IEEE International Symposium on Circuits and Systems held in London.

Andrew P. Sage (F) was chosen to receive the Donald G. Fink Prize for "Systems engineering and information technology: catalysts for total quality in industry and education," published in the *IEEE Transactions on Systems, Man, and Cybernetics* (Vol. 22, no. 5, September/October 1992, pp. 833–64).

Now dean of the School of Information Technology and Engineering at George Mason University (GMU), in Fairfax, Va., Sage earned his Ph.D. in 1960 from Purdue University, Lafayette, Ind., and taught at several universities before becoming a professor at GMU in 1984. His research interests include systems engineering and management efforts associated with decision support, command and control, the design and evaluation of information systems, and software systems engineering.

Among other prizes, Sage received the first Norbert Wiener Award and the IEEE's Centennial Medal. From 1984 to 1986 he was President of the Systems, Man, and Cybernetics (SMC) Society. He is editor of the *IEEE Transactions on Systems, Man, and Cybernetics; Automatica;* and *Information and Decision Technologies;* and of a John Wiley series of textbooks on systems engineering. Sage is to be presented with the Fink Prize on Oct. 3 during the IEEE International Conference on Systems, Man, and Cybernetics in San Antonio, Texas.

Oliver M. Collins (M) received the Browder J. Thompson Memorial Prize for "The subtleties and intricacies of building a constraint length 15 convolutional decoder" (*IEEE Transactions on Communications*, Vol. 40, no. 12, December 1992, pp. 1810–19).

Collins, an assistant professor since 1989 in the electrical and computer engineering department at The Johns Hopkins University, Baltimore, received a Ph.D. from the California Institute of Technology, Pasadena, that same year. He teaches courses on communications, information theory, coding, and complexity theory. He has also developed a technique for transferring power from the outer to the inner code in a concatenated coding system. His current research interests include radio system architectures, coding, and high-speed switching.

In 1994, Collins also received the Marconi Young Scientist Award. He was awarded the Thompson Prize on June 30 during the IEEE International Symposium on Information Theory held in Trondheim, Norway.

Washington watch

(Continued from p. 16T4)

Green, clean, and mean

The computer and electronics sector was one of six industry areas targeted by the Environmental Protection Agency (EPA) for participation in a new program that changes the way industries must control emissions toxic to the environment.

The program, called the Common Sense Initiative, seeks greater effectiveness at less cost to industry by revising the overall approach, from a pollutant-by-pollutant one to an industry-specific one, according to EPA chief Carol M. Browner.

The "fundamentally different" strategy, released in late July, calls for each industry group and the EPA to develop a blueprint based on six components:

- Review regulations in the industry to see if "cleaner" results can be obtained at less expense than in the past.
- Shift to pollution prevention (instead of cleaning up at the "end of the pipe" to meet minimum standards).
- Create electronic databases in order to avoid duplication of effort and to help disseminate environmental information to small businesses.
- Firmly but flexibly enforce emissions controls.
- Improve the processing of permits to companies so that public debate may be better informed and answers for industry be faster.
- Encourage new technology by not specifying how to achieve these goals.

The other sectors affected were automobile manufacture, iron and steel, metal finishing and plating, petroleum refining, and printing.

As a group, the six industries represent approximately 14 percent of the Gross Domestic Product and release 12.4 percent of all reported emissions nationally, or 180 million kilograms in 1992. In that year they spent $8.2 billion complying with environmental laws.

Satellite science lessons

Vice President Al Gore's pet international project, Globe, was endorsed by the IEEE–United States Activities in July. Globe gathers environmental data on the earth through the efforts of scientists, school teachers, and students in more than 40 countries.

In collecting the data and sharing it, students all over the globe—from Papua New Guinea and India to Germany and Japan—will use the emerging global information infrastructure. The project "will instill in students a lasting appreciation for and interest in science and technology," stated Charles Alexander, IEEE-USA chairman in a letter to U.S. senators. He urged that the Administration's request for $7 million for Globe next year be granted.

Software patents get expert help

Responding to industry concerns, the U.S. Patent and Trademark Office announced in June that it was hiring nine computer scientists as patent examiners for software-related filings. They are to be employed under a specially funded two-year program, whose usefulness will be assessed when it ends.

Software filings have grown steadily in number in recent years. In 1992, 7552 of the 185 000 filings were software related. And in 1993, a total of 2830 software patents were granted, according to Patent spokeswoman Ruth Ford. Commissioner Bruce Lehman predicted that the computer scientists will "step up the quality" of the patent examination process.

John A. Adam Washington Editor

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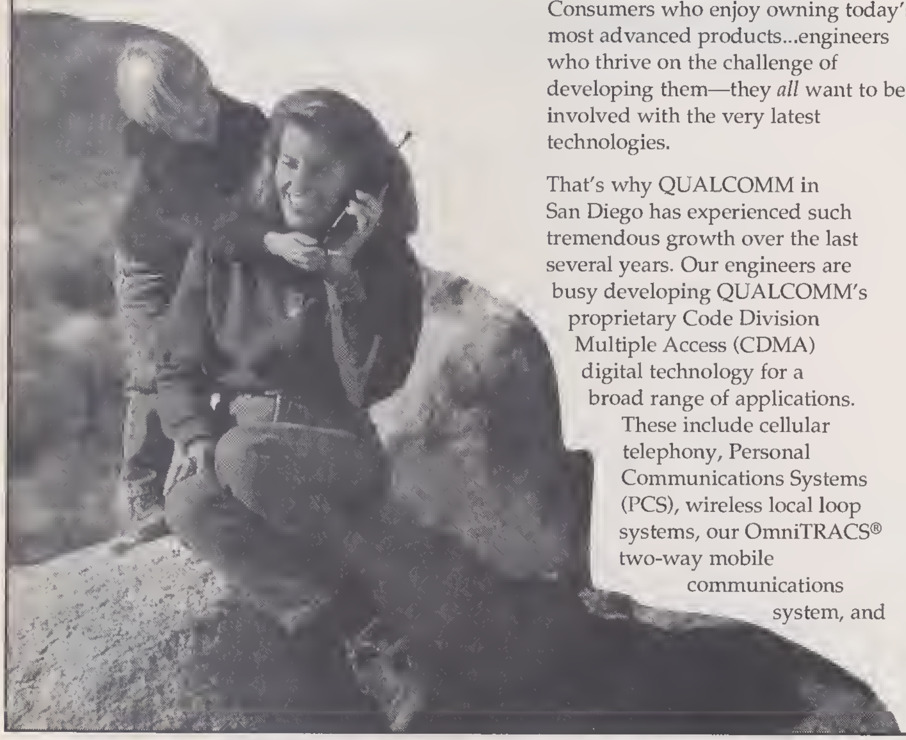

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DIVISION CHIEF: The Electronics Engineering Laboratory of the National Institute of Standards and Technology, Department of Commerce, is seeking to fill a Division Chief position in its Laboratory in Boulder Colorado. The Division Chief is the manager of an organization of approximately fifty people and has responsibility for staffing, budget, program development, and program assessment. The Division staff conduct basic and applied research required to provide measurement science needed by the magnetic recording industry, the superconductivity industry, and related industries. Candidates will have a Ph.D., or equivalent experience, in physics, electrical engineering, or a related discipline with experience in the Division's field of responsibility. In addition, they will have demonstrated skill and experience in dealing with the relevant industry sectors and technical management experience. Interested applicants are requested to call 303-497-6332 for a summary of the position requirements and application instructions Only those applications postmarked by November 1, 1994 will be considered.

The position is either a Supervisory Physical Scientist or Supervisory General Engineer, ZP-1301 or 0801-5, salary range $69,633-$96,033 depending upon qualifications and experience. Please send Personnel Qualifications Statement-SF-171 (Rev. 6/88) plus transcripts, a supplemental statement addressing the above elements, and proof, if claiming veteran's preference postmarked by 11/1/94 to:

Diann Benallo (NIST 94-331/DB), MASC Human Resources Division-MC23, 325 Broadway, Boulder, CO 80303.

NIST is an Equal Employment/Affirmative Action Employer, U.S. citizenship is required.

DEAN OF ENGINEERING AND TECHNOLOGY

Burlington County College (BCC) and the New Jersey Institute of Technology (NJIT) seek a Dean to lead their joint engineering and technology programs and BCC's related disciplines. Courses are currently taught at BCC's main campus in Pemberton, New Jersey, but will relocate when construction is completed at our new high-tech campus in Mt. Laurel, New Jersey.

BCC is a comprehensive community college serving one of the Northeast's fastest growing counties. NJIT is a public research university providing programs in engineering, architecture, industrial management and sciences.

Required qualifications include a Master's degree in engineering and technology. Doctorate with emphasis in Electrical Engineering preferred; experience as an administrator, preferably in higher education; professional experience including a minimum of 3 years relevant industrial experience as an engineer; teaching experience; background in relevant computer applications; and grants writing experience. Current valid professional engineer license preferred.

Applications will be accepted until September 30, 1994.

Qualified applicants are asked to submit a letter of interest and resume to: **Personnel Department, Burlington County College, County Route 530, Pemberton, New Jersey 08068.**

Affirmative Action/Equal Opportunity Employer (M/W). Women and minorities are encouraged to apply.

BURLINGTON COUNTY COLLEGE

NJIT
New Jersey Institute of Technology

SIEMENS

Our technology can help you find something exciting.

At Siemens Medical Systems, we're constantly advancing ultrasound imaging technology. It's the kind of important, challenging work that demands highly innovative and motivated professionals. If you have the rare qualities we seek, we invite you to contribute to our exciting achievements. Consider the following:

Senior Acoustic/Transducer Engineer

Optimize transducer design by using and developing simulation tools. Gather, analyze, and interpret measurement data by using existing and developing new experimental techniques. MSEE and 5+ years related experience required.

Senior/Staff Acoustics Engineer

Develop new medical diagnostic ultrasound transducers, including performance optimization and image quality analysis based upon acoustics and systems parameters. Integrate transducers into ultrasound systems. Simulate, specify and analyze transducer performance. PhD in EE or Physics with 5+ years medical ultrasound systems related experience required. Medical image analysis experience and knowledge of human anatomy as well as FDA 510 (k) process a plus.

Senior/Staff Software Engineer

Analyze, design, implement and document software/firmware development of assigned modules. Perform complex software system design engineering in diagnostic ultrasound with emphasis in control and DSP applications. BSEE, BSCS or equivalent, MSEE preferred and minimum 3 years working experience in C and/or C++ required. DSP with Image Processing background a must. Experience in a UNIX development environment developing real-time systems using Case tools necessary.

When you bring your abilities to Siemens, you'll enjoy competitive compensation and a comprehensive benefits package. For immediate consideration, please send your resume to: **Siemens Medical Systems, Inc., Ultrasound Group, Human Resources, P.O. Box 7002, Issaquah, WA 98027-7002.** We are an Equal Opportunity Employer and value the diversity of our team members.

Siemens Medical Systems, Inc.
Ultrasound Group

Senior Software Engineer/Group Leader Washington University

Opening for an energetic person to lead a group of three software developers in the design and implementation of an object oriented genetic mapping database system. Position requires a strong background in project management using C/C++ or Smalltalk-80/VisualWorks with at least 3-5 years experience in applications analysis and design, programming and support of GUI-based systems. Knowledge of genetics and genome analysis helpful but not required. Coding will be in smalltalk-80/VisualWorks using the GemStone database. Apply in writing to Dr. Helen Donis-Keller, Director, Division of Human Molecular Genetics, Department of Surgery.

Washington University
School of Medicine
Box 8109, 660 South Euclid
St. Louis, MO 63110
or by e-mail to
helen@hdklab.wustl.edu.

Recent books

(Continued from p. 13)

Technology of Object-Oriented Languages and Systems TOOLS 13. Eds. *Magnusson, Boris, et al.*, Prentice Hall, Englewood Cliffs, N.J., 1994, 549 pp., $60.

Energy Effective Industrial Illuminating Systems. *Chen, Kao*, Fairmont Press, Lilburn, Ga., 1994, 180 pp., $69.

The Worldwide Aeronautical Communications Frequency Directory, 2nd edition. *Evans, Robert E.*, Universal Radio Research, Reynoldsburg, Ohio, 1994, 260 pp., $19.95.

ISDN and Its Application to LAN Interconnection. *Deniz, Dervis Z.*, McGraw-Hill, New York, 1994, 254 pp., $35.

Optical Document Security. Ed. *van Renesse, Rudolf L.*, Artech House, Boston, 1994, 370 pp., $89.

Molecular Beam Epitaxy. Ed. *Cho, Alfred*, AIP Press, New York, 1994, 570 pp., $45.

Inside The Technical Consulting Business: Launching and Building Your Independent Practice, 2nd edition. *Kaye, Harvey*, John Wiley & Sons, New York, 1994, 237 pp., $34.95.

Introduction to Dynamic Systems Modeling for Design. *Smith, David L.*, Prentice Hall, Englewood Cliffs, N.J., 1994, 472 pp., $64.

The Maple V Handbook. *Abell, Martha L.*, Academic Press, New York 1994, 726 pp., $39.95.

Perturbation Signals for System Identifi cation. *Godfrey, Keith*, Prentice Hall, Englewood Cliffs, N.J., 1993, 439 pp., $88.

Microwave and Geometrical Optics. *Cornbleet, S.*, Academic Press, New York, 1994, 626 pp., $85.

Open VMS AXP Internals and Data Structures, Version 5.1. *Goldenbert, Ruth E.*, and *Saravanan, Saro*, Butterworth-Heinemann, Woburn, Mass., 1994, 1672 pp., $150.

Introduction to Radiometry and Photometry. *McCluney, Ross*, Artech House, Boston, 1994, 402 pp., $85.

Mechanics and Control. Ed. *Guttalu, Ramesh S.*, Plenum Press, New York, 1994, 356 pp., $95.

Electrical Safety: A Guide to the Causes and Prevention of Electrical Hazards. *Adams, J. Maxwell*, Institution of Electrical Engineers, London, 1994, 194 pp., $75.

Recent books

Harbrace ESL Workbook. *Graham, Sheila Y.*, and *Curtis, Wynn J.*, Harcourt Brace Jovanovich, New York, 1994, 431 pp., $16.25.

Frequency Synthesizer Design Handbook. *Crawford, James A.*, Artech House, Boston, 1994, 435 pp., $88.

Wireless Personal Communications: The Future of Talk. *Schneiderman, Ron*, IEEE Press, Piscataway, N.J., 1994, 193 pp., $29.95, $25 (member).

Operational Amplifier: Characteristics and Applications, 3rd edition. *Irvine, Robert G.*, Prentice Hall, Englewood Cliffs, N.J., 1994, 574 pp., $64.

OS/2 Connectivity and Networking: A Guide to Communications Manager/2. *Johnston, John E.*, McGraw-Hill, New York, 1994, 326 pp., $39.95.

Noise in Digital Optical Transmission Systems. *Jacobsen, Gunnar*, Artech House, Boston, 1994, 387 pp., $75.

Basic Concepts in Information Theory and Coding: The Adventures of Secret Agent 00111. *Golomb, Solomon W., et al.*, Plenum Press, New York, 1994, 431 pp., $59.50.

Methods in Electromagnetic Wave Propagation, 2nd edition. *Jones, D.S.*, Oxford University Press, New York, 1994, 655 pp., $120.

Intelligent Networks. *Thorner, Jan*, Artech House, Boston, 1994, 191 pp., $65.

General Electric at Fort Wayne, Indiana: A 110 Year History. *Linkous, Clovis E.*, Gateway Press, Baltimore, Md., 1994, 560 pp., $30.

Spread Spectrum Communications Handbook, revised edition. *Simon, Marvin K., et al.*, McGraw-Hill, New York, 1994, 1228 pp., $99.50.

Rightsizing the New Enterprise: The Proof, not the Hype. *Kern, Harris,* and *Johnson, Randy*, Prentice Hall, Englewood Cliffs, N.J., 1994, 326 pp., $38.

Internetworking with TCP/IP, Vol. II: Design Implementation and Internals. *Comer, Douglas E.*, and *Stevens, David L.*, Prentice Hall, Englewood Cliffs, N.J., 1994, 613 pp., $50.

Multimedia: Gateway to the Next Millennium. Eds. *Aston, Robert*, and *Schwarz, Joyce*, Academic Press, New York, 1994, 287 pp., $39.95.

EEs' tools & toys

Kit helps with design of fast VMEbus systems

Starter kit for AutoBahn Spanceiver VMEbus designs includes a modified backplane chassis in which the transmission lines linking the b21 and b22 pins of the P1 connectors [red] have an impedance of 50 Ω. Data can be transferred serially over those lines at rates as high as 200 MB/s (1.6 Gb/s).

PEP Modular Computers, the people who dreamed up the AutoBahn Spanceiver concept for ultrahigh-speed data communication, have announced the availability of a starter kit for new VMEbus designs. The kit consists of two Spanceiver boards, one or (optionally) two single-board computers, and a specially modified VME backplane. With these parts, users can build systems in which data moves between plug-in boards at rates as high as 200 MB/s. For the first seven slots in the backplane, pins b21 and b22 of connector P1 have a tightly controlled impedance of 50 Ω.

Under the Spanceiver concept, parallel data is converted into serial form, transmitted serially at very high speed (1.6 Gb/s), and then converted back into its usual parallel format. Key to the economic implementation of the concept is Motorola's MC100SX1451 Autobahn Spanceiver chip, which realizes the serial-to-parallel and parallel-to-serial converters, as well as the necessary line drivers, in very fast emitter-coupled logic.

Typical applications of the AutoBahn Spanceiver technology include medical imaging, military radar, and simulation—all of which require the movement of large amounts of data with minimal delay. The technology is also suitable for implementing high-speed multidrop, or bussed, serial channels. Such an architecture would let multiple processors (most particularly, digital signal processors) share large blocks of data efficiently.

Each mezzanine board holds 128 kB of 20-ns static RAM, fast interface circuitry for linking to a 32-bit parallel data source, an address counter, and circuitry for connecting pins b21 and b22 of P1 on the VME backplane.

With Kit A, the single PEP VM30 single-board computer plugs into bus slot 1, to serve as the VMEbus host. It connects to a Spanceiver mezzanine in slot 2. The second such mezzanine may be plugged into any of the remaining modified slots (3–7). With Kit B, the second VM30 plus its Spanceiver mezzanine form a self-hosted development environment.

Kit A is priced at US $4990, Kit B at $6295. Extra Spanceiver mezzanines sell for $690, AutoBahn backplanes for $590 each. *Contact: in Europe, PEP Modular Computers, Apfeltranger Straße 16, D-87600 Kaufbeuren, Germany, (49+8341) 430 20; in the Americas, PEP Modular Computers, 5010 E. Shea Blvd., Suite C226, Scottsdale, AZ 85254; 602-483-7100; fax, 602-483-7202; or* **circle 110.**

EDUCATION

Designing with FPGAs

Engineers interested in learning how to design with field-programmable gate arrays may enjoy a kit from Xess Corp. For less than $150, you will get both a basic text and a small circuit board that may be used to perform the experiments described in the book.

The text, titled *FPGA Workout: Beginning Exercises with the Intel FLEXlogic FPGA*, introduces the principles of digital logic design using the Intel NFX780 FPGA. Each chapter presents working examples of logic circuits that the reader can load into this FPGA and experiment with. Chapters include The Digital Design Process, Combinational Logic, Modular Designs and Hierarchy, Flip-Flops, Counters, State Machine Design, and Memories. In addition, several other chapters detail the architecture and design of a simple 4-bit microcomputer.

The board can stand alone or be mounted on a larger prototyping board. It has a socket for a single NFX780 FPGA, a 1-digit readout for displaying results, an interface cable for loading new circuits through a PC printer port, a 5-V regulator, and an interface for connecting multiple boards to create multiple-FPGA systems.

The complete kit, including an NFX780-15 FPGA, sells for $149.95. Without the FPGA, it goes for $99.95. The text alone is $19.95. *Contact: Dave Van den Bout, Xess Corp., Department SP, 2608 Sweetgum Dr., Apex, NC 27502; 919-387-1302; toll-free, 800-549-9377 (800-549-XESS); e-mail, devb@vnet.net; or* **circle 111.**

GENERAL INTEREST

Engineering bulletin board

The Engineers' Club (TEC) is an electronic bulletin board system for engineers and other members of the technical community. In addition to providing a forum for the exchange of ideas, TEC evaluates software and has compiled several technical libraries of professional quality shareware and freeware, according to Robert Griffith, the club's founder.

Over half TEC's capacity is dedicated to engineering software. The remainder is devoted to utilities and DOS file-handling software. A small amount, perhaps 10 percent, is taken up by games. Besides the on-line files, TEC also maintains many files on tape, which subscribers may access by request. All told, more than 4000 files are available.

Electronic mail is a large part of any bulletin board system (BBS) service today, and TEC is no exception. It offers Internet e-mail access and many technical news groups for subscribers. It also operates a technical mail area and a job hunters' conference.

Two kinds of membership to TEC are available. Paying members pay $35 a year, for which they get up to 90 minutes a day of download time. Contributing members contribute shareware and freeware files or else provide help to the board and its members. Either way, the more they contribute, the more download time they earn.

At present, TEC has over 1500 members from over 20 countries. The service is available 23 hours a day via four telephone lines. (The BBS is down every day from 0300 to 0400 PST for maintenance.)

Interested parties are invited to call and hang around the board for a few weeks to check it out. *Contact: The Engineers' Club, San Jose, Calif.; BBS, 408-265-3353; e-mail, TEC@engineers.com; CompuServe, 73061,3406@compuserve.com.*

E-mail made simple

While just about everyone acknowledges the value of e-mail, some find it more trouble than it's worth—especially for brief notes. Accessing the e-mail program, in some cases, requires more steps and takes longer than writing the message. Not so with QuickFlash.

A Windows-based network messaging system, QuickFlash requires no log-in steps

to send or receive communications. All it involves is clicking on the QuickFlash icon, typing the message, and clicking SEND. Using QuickFlash does not even require leaving the current application.

As well as text, QuickFlash messages may contain graphics, either captured from any part of the screen or drawn using a built-in drawing routine. The program also lets users send prefabricated messages like "Can we meet today?" and "You have a package" by clicking on a PRE-FAB menu.

Normally, received messages pop up as bright yellow "Post-It" type notes. Users who wish not to be distracted by such notes may invoke a "Do Not Disturb" feature, and retrieve messages at their convenience.

QuickFlash is priced at $249 for 10 users and $399 for 25. *Contact: ADM Group, 477 Madison Ave., New York, NY 10022; 212-750-7400; fax, 212-750-7419; or* **circle 112.**

DIGITAL SIGNAL PROCESSING

Evaluating DSPs

The trouble with standard benchmarks is that they are, well, standard. In the interests of meaningful comparison, they always compare apples with apples. But what if you're interested in buying a pear? What you really want is benchmark data on the performance of different DSP chips running your specific application.

Of course, that is asking a bit much. But the DSP Benchmark Analysis Tool from Berkeley Design Technology takes a meaningful step toward that goal by providing a library of standard benchmark data along with an analysis framework that lets users create customized analyses from that data.

What this analysis tool does is simplify the business of comparing DSPs with each comparison criterion weighted as required by a particular application. In addition, it allows users to create custom benchmarks by varying such benchmark parameters as number of samples for a fast Fourier transform or number of taps on a filter.

The DSP Benchmark Analysis Tool also helps chip makers perform WHAT-IF analyses on their products. With it they can quickly see the effect on benchmarks of changes in such parameters as processor speed.

Basically, the software product is a collection of Microsoft Excel spreadsheets containing the benchmark results and analyses used in Berkeley Design Technology's well-known *Buyer's Guide to DSP Processors*. It provides data on a dozen processors from the leading DSP makers.

A site license for the DSP Benchmark Analysis Tool costs $1450. It is sold as an adjunct to the buyer's guide, which is currently priced at $1850, but will go up to $2450 on Oct. 1. *Contact: Berkeley Design Technology Inc., 39355 California St., Suite 206, Fremont, CA 94538; 510-791-9100; fax, 510-791-9127; e-mail, info@bdti.com; or* **circle 113.**

NEW AND NOTEWORTHY

• The ITT Gallium Arsenide Technology Center, Roanoke, Va., is selling **a high-gain power amplifier for wireless communications systems.** The two-stage ITT555 MMIC produces 500 mW in the 1800–1900-MHz band from a single 3-V battery. In a 16-pin small-outline IC package, the amplifier costs under US $10 in 1000-piece lots. **Circle 114.**

• Associated Components Technology, Garden Grove, Calif., has **a surface-mount electromagnetic-interference suppressor chip** with a comparatively high rating for a chip bead of 1500 mA (max). The BCB-1812-1.5A is aimed at applications like the motor start/stop operation of disk and tape drives, where high current is maintained or where large current spikes develop. Unit price is $.085 in quantities of 100 000. **Circle 115.**

• Spyglass, Savoy, Ill., has added Spyglass Slicer, **a volumetric data analysis tool** for Windows/Windows NT, to its line. The

Tools & toys

$695 package reads a variety of data and image formats, including HDF, netCDF, and binary and Ascii matrices. **Circle 116.**

• Entrelec Inc., Irving, Texas, has a pair of **rail-mounted surge protector modules** designed for data communications circuits. Additions to the company's Series 800 line, the new modules protect RS-232, RS-422, and RS-485 data lines with transmission speeds to 1 MHz, withstanding peak surges of 6 kV and 3 kA lasting for 20–50 µs. **Circle 117.**

• Communication Automation & Control Inc., Allentown, Pa., is offering **an S-bus board based on AT&T Corp.'s DSP32C** floating-point digital signal processor. An SB32C1 board with one processor has a peak performance of 25 Mflops and provides one stereo codec and 512 kB of private static RAM. The dual-processor SB32C provides up to 50 Mflops, 1 MB of private SRAM, and four CD-quality audio I/O channels. **Circle 118.**

• Hewlett-Packard Co., Palo Alto, Calif., has introduced **an emulator for the Intel 80386DX microprocessor.** The HP 64789A provides real-time, zero-wait-state emulation to 33 MHz, and can support all addressing modes. This latter capability facilitates code reuse and smoothes the upgrade path from 8- and 16-bit Intel processors. **Circle 119.**

• Toshiba America Electronic Components Inc., Irvine, Calif., has introduced **a CMOS op amp IC** meant to dissipate less power and offer a wider dynamic range than conventional bipolar designs. The TC75S51F is supplied in a five-pin SOT-23 package and operates from a 1.5–7 V supply, from which it draws just 60 µA. It costs $0.65 in 10 000-piece quantities. **Circle 120.**

• Texas Instruments Inc. in Houston, has announced **a digital signal-processing chip** for the baseband functions of next-generation, portable digital cellular telephones. The TMS320C57 includes a high-performance C5x-series DSP central processing unit, sufficient on-board memory to implement digital cellular phone standards worldwide, such as IS-54, PDC, and GSM, and two intelligent peripherals—a buffered serial port and a host processor interface. The chip is built with a 3-V CMOS process and can run at a sustained throughput of 40 MIPS; slower 2-V operation is also possible. Samples will be available in the fourth quarter. **Circle 121.**

• Analog Devices Inc., Norwood, Mass., has a pair of analog-to-digital **converters for high-resolution precision medical and industrial applications.** The AD7716 holds four independent 22-bit converters, each with a 110-dB dynamic range, for use in medical and instrumentation systems; the AD7714 is a 24-bit, low-power converter optimized for industrial and process control, with a five-channel programmable gain front end. **Circle 122.**

• Signal Processing Associates Pty, Blackburn, Victoria, Australia, has a speech compression audio **codec that provides high-quality voice at a rate of 16 kb/s.** The device's performance approaches the quality of 64-kb/s pulse-code–modulated voice, according to the company. The low-rate voice-encoding software algorithm is based on the international standard recommendation ITU/CCITT G.728, which relies on low-delay codebook-excited linear prediction (LD-CELP). The code is provided on a fixed-point 33-MIPS ADSP-2171 digital signal processor from Analog Devices. **Circle 123.**

• Lattice Semiconductor Corp., Hillsboro, Ore., has introduced a pair of 3.3-V CMOS progammable logic devices. The GAL16-LV8ZD and GAL20LV8ZD families can also be used for mixed 3.3- and 5-V systems. At 3.3 V, the chips typically consume 45 mA (I_{cc}) at clock speeds to 62.5 MHz (F_{max}). They're available in 15- and 25-ns versions. **Circle 124.**

COORDINATOR: Michael J. Riezenman

CONSULTANT: Paul A.T. Wolfgang, Boeing Defense & Space Group

CLASSIFIED EMPLOYMENT OPPORTUNITIES

The following listings of interest to IEEE members have been placed by educational, government, and industrial organizations as well as by individuals seeking positions. To respond, apply in writing to the address given or to the box number listed in care of *Spectrum* Magazine, Classified Employment Opportunities Department, 345 E. 47th St., New York, N.Y. 10017.

ADVERTISING RATES

Positions open—$40.00 per line, not agency-commissionable.

Positions wanted—$40.00 per line, a 50% discount for IEEE members who supply their membership numbers with advertising copy.

All classified advertising copy must be received by the 25th of the month, two months preceding the date of issue. No telephone orders accepted. For further information call 212-705-7578.

IEEE encourages employers to offer salaries that are competitive, but occasionally a salary may be offered that is significantly below currently acceptable levels. In such cases the reader may wish to inquire of the employer whether extenuating circumstances apply.

Academic Positions Open

Department Head, Bradley Department of Electrical Engineering, Virginia Polytechnic Institute and State University: Nominations and applications are being solicited for the position of Head of the Harry Lynde Bradley Department of Electrical Engineering. Nominations and applications will be accepted until suitable candidates are selected and will be reviewed beginning October 1, 1994. The selection is expected to be made in late fall, with the appointment to begin no later than the summer of 1995. Candidates should have achieved distinction in university teaching and research and a record of demonstrated scholarship and administrative ability. They must qualify for the rank of full professor. The Department offers B.S. degree programs in both Electrical Engineering and Computer Engineering and M.S. and Ph.D. degree programs in Electrical Engineering. The Department has 55 full-time faculty members, 820 undergraduate students, 368 on-campus graduate students, and is the beneficiary of the Bradley endowment. New externally funded research grants and contracts during the past year totaled $7 million. A generous overhead return policy provides additional Departmental income. Virginia Tech is the senior land-grant university of the Commonwealth, located in Blacksburg adjacent to the scenic Blue Ridge Mountains. Highly selective in admissions, the University enrolls in its nine colleges some 18,000 undergraduate students and 4,500 graduate and professional students. The College of Engineering was the first among major public institutions to require each student to have a personal computer and its graduate and undergraduate programs are ranked nationally. Applications should include a current resume and the names, affiliations, and telephone numbers of at least three references. Send applications and nominations to: Dr. Gary S. Brown, Chair, Search Committee, Bradley Department of Electrical Engineering, Virginia Tech, Blacksburg, VA 24061. Virginia Tech has a strong commitment to the principle of diversity and, in that spirit, seeks a broad spectrum of candidates including women, people of color, and people with disabilities. Individuals with disabilities desiring accommodation in the application process should notify Kathy Atkins, Electrical Engineering Department, 703-231-4136 or TDD/PC - 1-800-828-1120 or Voice - 1-800-828-1140.

Hong Kong University of Science and Technology - Department of Electrical & Electronic Engineering invites application for tenure-track faculty positions for all ranks (Professor, Reader, Senior Lecturer and Lecturer) for openings starting in January and July 1995. The EEE Department at HKUST was established in 1991 and offers BEng. in Electronic Engineering and MSc., MPhil. and Ph.D in Electrical and Electronic Engineering. The Department currently has over 500 undergraduate students and 120 postgraduate students with about 40 full time faculty members and 40 support staff. We are expecting to have 10 new faculty openings in 1995 to allow the Department to grow to 50 full time faculty members. The Department is planning to reach a full size of 65 full time faculty members by 1998 with more than 100 support and research staff. The Department has major research interests in Integrated Circuits Design; Microelectronics; Photonics; Sensors and Instrumentation Systems; Communications and Control; Circuits, Signals and Systems; Robotics and CAD/CAM; Computer Engineering and Bioengineering. We are particularly interested in qualified applicants with relevant teaching and research experience in VLSI Circuits Design and Tests, Microelectronics Devices and Technology, Photonics, Optoelectronics, Microwave Electronics, Microsensors and Micromachines, Biomedical Sensors and Bioinstrumentation, Circuits and Systems Theory, Signal Processing, Wireless Communications, Video Technology, Robotics and Control. We are also interested in applicants with expertise in Computer Architecture, Computer Hardware Design and Computer Networking for our Computer Engineering Programme. Applicants should have a PhD with demonstratable experience in teaching and research. We are particularly interested in applicants in the areas of microelectronics, communications, networking and computer engineering for senior faculty openings. The Department has excellent facilities for teaching and research with 20 modern teaching and research laboratories. The University has central research facilities including a complete Microelectronics Fabrication Centre (MFC) and a well-equipped Material Preparation and Characterization Centre (MCPC). All formal instructions are given in English. Salary ranges are from USD 48,400 to USD 80,800 per annum for Lecturer; USD 75,100 to USD 104,100 per annum for Senior Lecturer and Reader; and a minimum of USD 107,300 per annum for Professor in 1993-4. Salaries in 1994-5 are expected to increase by approximately 9%. General fringe benefits including medical and dental benefits, annual leave, and children's education allowances are provided. Air passages and housing are also provided where applicable. Initial appointments will generally be on three-year contract terms; a gratuity of 25% of the total basic salary drawn will be payable upon successful completion of contract. Re-appointment after the initial contract will be subject to mutual agreement. Applications including full curriculum vitae, list of publication, and names, addresses and phone numbers of at least five references should be directed to: Professor Peter Cheung, Head, Department of Electrical and Electronic Engineering, Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong. Applications will be considered until all the positions are filled.

Washington State University at Tri-Cities, School of Electrical Engineering and Computer Science: One faculty position at the Assistant or Associate Professor level is available starting at the beginning of the 1995-96 academic year, sited at WSU Tri-Cities in Richland, WA. A PhD in electrical engineering or a closely related field is required. The successful candidate will contribute to instruction at the undergraduate and graduate levels in electrical engineering and maintain an active research program. Areas of research interest include power, computer engineering, the nondestructive testing of materials, and electromagnetic field theory. Industrial experience is desirable. Applicants should provide a resume and a list of three references including addresses, phone numbers and the rank they are applying for. First deadline for applications is October 30, 1994 but applications will be entertained until position is filled. Address correspondence: Chair, Search Committee EECS, WSU Tri-Cities, 100 Sprout Road, Richland, WA 99352. WSU is an EO/AA educator and employer. Protected group members are encouraged to apply.

University of California, Los Angeles expects to have several openings in tenured and tenure track faculty positions in the Electrical Engineering Department. Applications are accepted in the areas including, but not limited to, Microsensors, Communications and Networking, Signal Processing, Multi-Media, Wireless Technology, IC Design, and Massively Parallel Computing. Applicants should have a Ph.D. and an outstanding research record in their expertise. Industrial and/or academic experience is preferred. Rank and salary are commensurate with the record of the successful candidate. Letters of application should be mailed to Professor T. Itoh, Recruiting Committee Chairman, Electrical Engineering Department, UCLA, 405 Hilgard Ave., Los Angeles, CA 90024-1594. UCLA is an Equal Opportunity/Affirmative Action Employer.

C3-Professur Neuroinformatik am Institut für Neuroinformatik der Ruhr-Universität Bochum zu besetzen. Das Institut ist eine zentrale wissenschaftliche Einrichtung der Universität mit den Abteilungen Systembiophysik und Theoretische Biologie. Arbeitsschwerpunkte sind Prinzipien der Selbstorganisation und Informationsverarbeitung in neuronaler Architektur. Die Position schließt die Mitwrkung der kollegialen Leitung des Instituts ein. Zu den Lehraufgaben gehören Vorlesungen über Neuronale Netze sowie über technisch nutzbare Organisationsprinzipien biologischer neuronaler Systeme. Es wird erwartet, daß die zu berufende Persönlichkeit mindestens in einem der folgenden Gebiete wissenschaftlich ausgewiesen ist: 1. Analyse und Anwendung biologischer neuronaler Organisationsprinzipien; 2. Künstliche Neuronale Netze; 3. Entwurf von Systemen in neuronaler Architektur; 4. Probleme der Selbstorganisation. Neben Erfahrungen im theoretischen Bereich (Systemtheorie, nichtlineare Dynamik) wird Interesse an anwendungsorientierten Problemen vorausgesetzt. Eine Kooperation mit dem Zentrum für Neuroinformatik in Bochum, das bevorzugt anwendungsorientierte Probleme bearbeitet, ist möglich. Die Ruhr-Universität Bochum bemüht sich um die Förderung von Frauen in Forschung und Lehre. Schwerbehinderte werden bei gleicher Qualifikation bevorzugt. Ihre schriftliche Bewerbung mit den üblichen Unterlagen richten Sie bitte an den Rektor der Ruhr-Universität Bochum, D-44780 Bochum, Germany.

Assistant Professor, Bioengineer: The Institute of Gerontology at the University of Michigan invites applications from bioengineers studying muscle contractility at the single cell level with emphasis on the role of the individual protein components and other regulatory factors. Candidates should have a Ph.D. in bioengineering, or in another field of engineering, with evidence of training in muscle physiology. A minimum of two years of postdoctoral experience is required. The candidate is expected to develop an independent research program, participate in an interdisciplinary group investigating molecular and cellular mechanisms of skeletal muscle impairments in old animals, and teach in graduate and professional courses. A joint tenure-track appointment as an Assistant Professor in an appropriate academic department is negotiable. Applicants should send a letter of interest with summary of past research experience and current/future goals, a CV with list of past and current research support, and also should arrange forwarding of at least three letters of recommendation to: Dr. Richard C. Adelman, Director, Institute of Gerontology, University of Michigan, 300 N. Ingalls, Ann Arbor, MI 48109-2007. Review of the applications will begin on November 1, 1994 and continue until a suitable candidate is identified. The University of Michigan is an Affirmative Action/Equal Opportunity Employer.

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tectures and systems. The applicant should have expertise in one or more application areas of photonic networks, such as telecommunication or distributed computing. He/she should have experience in integration of devices, components or sub-systems into a photonic network system. The candidate in image/signal processing should be interested in dealing with signals to process them for different applications. A strong person with training in image processing may also satisfy this need. This person is likely to be a resource for disparate areas ranging from medical image processing to scanning probe microscopy. Candidates must have a Ph.D. and a strong interest in graduate and undergraduate teaching. Salary and rank are commensurate with experience and qualifications and based on UC pay scales. Applications received by December 31, 1994 will be considered. Applicants should send a current resume and the names of three to five references to: Professor William S.C. Chang, Chair, Department of Electrical and Computer Engineering, University of California, San Diego, 9500 Gilman Drive, Mail Code 0407, La Jolla, CA 92093-0407. Immigration status of non-citizens should be stated in the dossier. UCSD is an Equal Opportunity/Affirmative Action Employer.

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Technische Universität München, Germany: The Department of Electrical Engineering is seeking nominations and applications for the position of Department Chairperson for Electronic Engineering, effective April 1, 1996. Responsibilities include teaching graduate courses in the field of semiconductor devices and advanced microelectronics manufacturing science and technology. A well equipped laboratory for silicon based device research will be provided for the successful candidate. Minimum requirements are a doctorate in electrical engineering or related field, a distinguished record in research, as well as industrial experience in microelectronics. Fluent German is necessary for teaching. Age should not exceed 52 years at date of appointment.

Missouri, Columbia, Missouri 65211. Immigration status of non-United States citizens should be stated. Affirmative Action/Equal Opportunity Employer.

North Carolina A&T State University, Greensboro, NC, Department Chairperson position in Computer Science: The department of Computer Science, College of Engineering, North Carolina A&T State University invites application for the position of Department Chairperson. Applicants must hold the Ph.D. in Computer Science, have previous chair experience, previous funded research, and demonstrated ability to develop new graduate programs at the masters and doctoral levels. Screening will begin immediately for a starting date of January 1, 1995. Applications must be received by Nov 1, 1995. Senior Faculty position in Computer Science: The department of Computer Science, College of Engineering, North Carolina A&T State University invites applications for a Senior Faculty position. All areas of computer science will be considered. Preference will be given to applicants with a research record in software engineering or artificial intelligence. All candidates must have a doctorate in Computer Science. The successful candidates must show exceptional scholarship and have a proven record of attracting sustained research funding. This person is expected to provide leadership in research and graduate education. Position will be open until filled. Please send letter of application, a resume and three references to: R.E. Harrigan, Chairman of the Search Committee, NCA&T State University, Graham Hall, Room 114, Greensboro, NC 27411. Indication of sex and ethnicity for affirmative action statistical purposes is requested, but not required.

Technology policy, manufacturing, and green design are areas of teaching and research interest for which we currently seek faculty at any level and in Carnegie Mellon's Department of Engineering and Public Policy. A 50:50 joint appointment with the Department of Mechanical Engineering is also available. Require excellent engineering skills and demonstrated research track record. Prefer economic and social science literacy. Resume and best papers to Granger Morgan, EPP, Carnegie Mellon, Pittsburgh, PA 15213.

Faculty Position: Division Chair and Associate/Professor of Electronics Engineering Technology (starting January 1995): Has college-wide administrative responsibilities as assigned by the Dean. Supervises staff and faculty in EET, CENT, CST, and APSM programs. Earned Doctorate in engineering, engineering technology or related technical area; three years related industrial experience and suitable administrative

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...0 University Street, Montreal, Quebec, H3A 2A7, Canada. In accordance with Canadian Immigration requirements, this advertisement is directed to Canadian citizens and permanent residents of Canada. McGill University is committed to equity in employment.

Assistant Professor, Dept of Electrical and Computer Engineering, The University of Texas at El Paso: UTEP invites applications for a tenure-track Assistant Professor position in the area of digital systems design & testing. A doctorate in either electrical engineering or computer engineering is required. The successful candidate will be expected to participate in teaching of both undergraduate & graduate students as well as the development of a research program. Anticipated starting date is 01-15-95. Applications should include a resume, names & addresses of at least three references & a statement of career objectives send to Dr. Michael E. Austin, UTEP Dept of Electrical & Computer Engineering, El Paso, TX 79968-0523. Deadline for receipt of applications is 10-01-94. The immigration status of non-U.S. citizens must be indicated clearly in the application. UTEP does not discriminate on the basis of race, color, national origin, sex, religion, age or disability in employment or the provision of services.

New Mexico State University: Tenure and non-tenure faculty positions at all professorial and instructor levels are expected to be available with the Klipsch Department of Electrical and Computer Engineering. A Ph.D. in EE or ECE is required for the professorial ranks. Instructor positions are available for qualified doctoral students. Applications from all areas in EE or ECE will be considered; however, Electronics/VLSI and Digital Signal Processing/Telecommunications are of special interest. Please indicate area(s) of specialization. Send applications to Dr. Don Merrill, Head ECE, Box 30001, Dept. 3-0, New Mexico State University, Las Cruces, NM 88003. Initial Screening will begin in Oct. 1994; however, applications will continue to be accepted and evaluated until positions are filled. New Mexico State University is an equal opportunity/affirmative action employer. Employment contingent on verification of eligibility for employment in the U.S.

The Ohio State University, Department of Electrical Engineering, invites applications for a tenure-track position in all areas related to Electromagnetics. While all levels will be considered, particular emphasis will be given to candidates at the Assistant or Associate Professor levels. Applicants must have a Ph.D. degree in Electrical Engineering or related field, outstanding academic credentials, potential for developing research programs, and an interest in teaching at the undergraduate and graduate

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Department Head, Bradley Department of Electrical Engineering, Virginia Polytechnic Institute and State University: Nominations and applications are being solicited for the position of Head of the Harry Lynde Bradley Department of Electrical Engineering. Nominations and applications will be accepted until suitable candidates are selected and will be reviewed beginning October 1, 1994. The selection is expected to be made in late fall, with the appointment to begin no later than the summer of 1995. Candidates should have achieved distinction in university teaching and research and a record of demonstrated scholarship and administrative ability. They must qualify for the rank of full professor. The Department offers B.S. degree programs in both Electrical Engineering and Computer Engineering and M.S. and Ph.D. degree programs in Electrical Engineering. The Department has 55 full-time faculty members, 820 undergraduate students, 368 on-campus graduate students, and is the beneficiary of the Bradley endowment. New externally funded research grants and contracts during the past year totaled $7 million. A generous overhead return policy provides additional Departmental income. Virginia Tech is the senior land-grant university of the Commonwealth, located in Blacksburg adjacent to the scenic Blue Ridge Mountains. Highly selective in admissions, the University enrolls in its nine colleges some 18,000 undergraduate students and 4,500 graduate and professional students. The College of Engineering was the first among major public institutions to require each student to have a personal computer and its graduate and undergraduate programs are ranked nationally. Applications should include a current resume and the names, affiliations, and telephone numbers of at least three references. Send applications and nominations to: Dr. Gary S. Brown, Chair, Search Committee, Bradley Department of Electrical Engineering, Virginia Tech, Blacksburg, VA 24061. Virginia Tech has a strong commitment to the principle of diversity and, in that spirit, seeks a broad spectrum of candidates including women, people of color, and people with disabilities. Individuals with disabilities desiring accommodation in the application process should notify Kathy Atkins, Electrical Engineering Department, 703-231-4136 or TDD/PC - 1-800-828-1120 or Voice - 1-800-828-1140.

Hong Kong University of Science and Technology - Department of Electrical & Electronic Engineering invites application for tenure-track faculty positions for all ranks (Professor, Reader, Senior Lecturer and Lecturer) for openings starting in January and July 1995. The Department is particularly interested in applicants in the areas of microelectronics, communications, networking and computer engineering for senior faculty openings. The Department has excellent facilities for teaching and research with 20 modern teaching and research laboratories. The University has central research facilities including a complete Microelectronics Fabrication Centre (MFC) and a well-equipped Material Preparation and Characterization Centre (MCPC). All formal instructions are given in English. Salary ranges are from USD 48,400 to USD 80,800 per annum for Lecturer; USD 75,100 to USD 104,100 per annum for Senior Lecturer and Reader; and a minimum of USD 107,300 per annum for Professor in 1993-4. Salaries in 1994-5 are expected to increase by approximately 9%. General fringe benefits including medical and dental benefits, annual leave, and children's education allowances are provided. Air passages and housing are also provided where applicable. Initial appointments will generally be on three-year contract terms; a gratuity of 25% of the total basic salary drawn will be payable upon successful completion of contract. Re-appointment after the initial contract will be subject to mutual agreement. Applications including full curriculum vitae, list of publication, and names, addresses and phone numbers of at least five references should be directed to: Professor Peter Cheung, Head, Department of Electrical and Electronic Engineering, Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong. Applications will be considered until all the positions are filled.

Washington State University at Tri-Cities, School of Electrical Engineering and Computer Science: One faculty position at the Assistant or Associate Professor level is available starting at the beginning of the 1995-96 academic year, sited at WSU Tri-Cities in Richland, WA. A PhD in electrical engineering or a closely related field is required. The successful candidate will contribute to instruction at the undergraduate and graduate levels in electrical engineering and maintain an active research program. Areas of research interest include power, computer engineering, the nondestructive testing of materials, and electromagnetic field theory. Industrial experience is desirable. Applicants should provide a resume and a list of three references including addresses, phone numbers and the rank they are applying for. First deadline for applications is October 30, 1994 but applications will be entertained until position is filled. Address correspondence: Chair, Search Committee EECS, WSU Tri-Cities, 100 Sprout Road, Richland, WA 99352. WSU is an EO/AA educator and employer. Protected group members are encouraged to apply.

Analyse und Anwendung biologischer neuronaler Organisationsprinzipien; 2. Künstliche Neuronale Netze; 3. Entwurf von Systemen in neuronaler Architektur; 4. Probleme der Selbstorganisation. Neben Erfahrungen im theoretischen Bereich (Systemtheorie, nichtlineare Dynamik) wird Interesse an anwendungsorientierten Problemen vorausgesetzt. Eine Kooperation mit dem Zentrum für Neuroinformatik in Bochum, das bevorzugt anwendungsorientierte Probleme bearbeitet, ist möglich. Die Ruhr-Universität Bochum bemüht sich um die Förderung von Frauen in Forschung und Lehre. Schwerbehinderte werden bei gleicher Qualifikation bevorzugt. Ihre schriftliche Bewerbung mit den üblichen Unterlagen richten Sie bitte an den Rektor der Ruhr-Universität Bochum, D-44780 Bochum, Germany.

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bridge the current gap between computer architecture and digital communication and networking. The candidate should have a thorough understanding and hopefully a practical expertise in the new multiprocessor networking systems. Some of the research issues in this area that need to be addressed are: network topology-efficient techniques for memory consistency; node arbitration for real-time communications and computing; techniques for the efficient mapping, partitioning and scheduling of programs onto multiprocessor systems with very high throughput, multiplexed, communication links. The applicant in data compression should have a broad interest in the use of such techniques to support advances in multimedia applications to wireless communications. This includes both voice, data and video compression techniques, as well as system level designs to facilitate bandwidth-on-demand and quality-of-service needs of subscribers. The applicant in r.f. circuits should be interested in a wide range of wireless communication applications and should have expertise in some or all of the following topics: amplifier/system noise analysis, high dynamic range mixers, power amplifiers, filter requirements and implementation, frequency synthesizers and architecture, a/d converters, and DSP functions for communication systems. The candidate in electronic circuits and systems should be an expert in VLSI design. This person will be interested in one or more of the following areas: design of mixed analog/digital IC's. High-speed electronic circuits and systems. Low power electronics and VLSI algorithms and architecture for signal and image processing, and communication systems. The photonic network position will fill our needs in the area of photonic information network architectures and systems. The applicant should have expertise in one or more application areas of photonic networks, such as telecommunication or distributed computing. He/she should have experience in integration of devices, components or sub-systems into a photonic network system. The candidate in image/signal processing should be interested in dealing with signals to process them for different applications. A strong person with training in image processing may also satisfy this need. This person is likely to be a resource for disparate areas ranging from medical image processing to scanning probe microscopy. Candidates must have a Ph.D. and a strong interest in graduate and undergraduate teaching. Salary and rank are commensurate with experience and qualifications and based on UC pay scales. Applications received by December 31, 1994 will be considered. Applicants should send a current resume and the names of three to five references to: Professor William S.C. Chang, Chair, Department of Electrical and Computer Engineering, University of California, San Diego, 9500 Gilman Drive, Mail Code 0407, La Jolla, CA 92093-0407. Immigration status of non-citizens should be stated in the dossier. UCSD is an Equal Opportunity/Affirmative Action Employer.

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University of Missouri-Columbia: The Department of Electrical and Computer Engineering invites applications for tenure-track positions at the assistant, associate, or full professor levels in the areas of computer engineering or computer science. The department currently has strong research programs in computer vision/pattern recognition, fuzzy set theory and applications, materials and solid state, and power electronics. Preference will be given to candidates with backgrounds in computer architecture or software engineering who are interested in research interactions with faculty in the computer vision and fuzzy logic areas. Responsibilities include teaching undergraduate and graduate courses, student advising, and developing and conducting sponsored research programs. Candidates must have an earned doctorate in Electrical Engineering, Computer Engineering, or Computer Sciences, and the potential for and commitment to developing sponsored research. Interested applicants should send a resume, a description of teaching and research interests, and a list of three references to: Cyrus O. Harbourt, Interim Chair, Department of Electrical and Computer Engineering, University of Missouri, Columbia, Missouri 65211. Immigration status of non-United States citizens should be stated. Affirmative Action/Equal Opportunity Employer.

North Carolina A&T State University, Greensboro, NC, Department Chairperson position in Computer Science: The department of Computer Science, College of Engineering, North Carolina A&T State University invites application for the position of Department Chairperson. Applicants must hold the Ph.D. in Computer Science, have previous chair experience, previous funded research, and demonstrated ability to develop new graduate programs at the masters and doctoral levels. Screening will begin immediately for a starting date of January 1, 1995. Applications must be received by Nov 1, 1995. Senior Faculty position in Computer Science: The department of Computer Science, College of Engineering, North Carolina A&T State University invites applications for a Senior Faculty position. All areas of computer science will be considered. Preference will be given to applicants with a research record in software engineering or artificial intelligence. All candidates must have a doctorate in Computer Science. The successful candidates must show exceptional scholarship and have a proven record of attracting sustained research funding. This person is expected to provide leadership in research and graduate education. Position will be open until filled. Please send letter of application, a resume and three references to: R.E. Harrigan, Chairman of the Search Committee, NCA&T State University, Graham Hall, Room 114, Greensboro, NC 27411. Indication of sex and ethnicity for affirmative action statistical purposes is requested, but not required.

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Chair in Photonic Systems: The Department of Electrical Engineering of McGill University is seeking an incumbent for its Chair in Photonics Systems. This Chair is funded by Bell Northern Research and Northern Telecom Ltd, McGill University and the Natural Sciences and Engineering Research Council (NSERC) of Canada through their Industrial Research Chair (IRC) program. The successful candidate must be an internationally recognized authority, preferably working at the interface between photonic devices and systems, with outstanding scientific and leadership qualities that can maintain the Department of Electrical Engineering at the forefront of research in Photonic Systems. An important condition for achieving this goal is the appointee's ability to strengthen our academic programs for both graduate and undergraduate students. The position carries a highly competitive salary, junior faculty positions specifically designated in Photonics systems, necessary laboratory space and, above all, strong University support for the above stated goals. Enquiries including an updated Curriculum Vitae and the names of at least three references should be sent to Professor Nicholas C. Rumin, Chairman, Department of Electrical Engineering, McGill University, 3480 University Street, Montreal, Quebec, H3A 2A7, Canada. In accordance with Canadian Immigration requirements, this advertisement is directed to Canadian citizens and permanent residents of Canada. McGill University is committed to equity in employment.

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levels. Send resume and names and addresses of references to: Professor Yuan F. Zheng, Chairman, Department of Electrical Engineering, The Ohio State University, 2015 Neil Avenue, Columbus, OH 43210-1272. The Ohio State University is an equal opportunity/affirmative action employer.

Dean, School of Engineering: The University of California, Irvine invites applications and nominations for the position of Dean of the School of Engineering. We seek an individual with an outstanding national and international reputation who will bring vision and innovative leadership to the School. Candidates must have a demonstrated commitment to academic excellence and diversity with administrative and interpersonal skills to further advance the School's standing in research, education, and service, and to strengthen industrial interactions. The scholarly achievements of this individual should be appropriate for an appointment as a Full Professor in one of the departments in the School. The School of Engineering currently contains 70 faculty, and four academic departments: Chemical and Biochemical Engineering, Civil and Environmental Engineering, Electrical and Computer Engineering, and Mechanical and Aerospace Engineering. Applications and nominations will be received until the position has been filled. However, the screening process will begin after November 1, 1994, and individuals are encouraged to apply prior to that date. Nominations and expressions of interest, along with curriculum vitae and the names and addresses of three referees, should be submitted to: Dean of Engineering Search Committee, c/o Patricia A. Adams, Office of Academic Affairs, 515 Administration, University of California, Irvine, CA 92717. The University of California, Irvine is an equal opportunity/affirmative action employer committed to excellence through diversity.

Naval Postgraduate School, Faculty Positions: Department of Aeronautics and Astronautics seeks applications for a Tenure Track position in the following area: Avionics - Applicants for the Avionics position should have experience (either industrial or academic) in the development of avionic related items, be knowledgeable in digital control, familiar with the integration of aerodynamic, propulsion and navigation concepts, U.S. citizenship is required. Tenure tracks and teaching adjunct positions will also be considered in Aerodynamics/Fluid Mechanics, Flight/Mechanics/Controls, Structures and Design. Research experience involving helicopters is particularly desirable. Candidate must have a Ph.D. in aerospace or related fields, demonstrated research and teaching ability and will be required to teach and perform research at the graduate level. Good communication skills, both oral and written, are essential. In addition to 16 tenure track and 4 adjunct faculty, the department has 15 support staff and offers both M.S. and Ph.D. degrees. Applications will be accepted until the position is filled. Please send resume and names of three references to: Dr. D.J. Collins, Chairman, Department of Aeronautics and Astronautics, Naval Postgraduate School, Monterey, CA 93943. (408) 656-2311. The Naval Postgraduate School is an Equal Opportunity/Affirmative Action Employer.

Faculty Appointments in Advanced Materials: The University of Massachusetts Lowell has established a Center for Advanced Materials. The focus of the Center is the design, synthesis, processing, characterization, and application of advanced materials in the fields of polymers, polymer-ceramic interfaces, biomaterials, electronics, photonics, and opto-electronics. The Center incorporates an extensive suite of modern, state-of-the-art instrumentation. Currently, the University is establishing a Materials Science/ Engineering graduate degree program with participation from a number of academic departments including the departments of Chemistry, Physics, Chemical & Nuclear Engineering, Electrical Engineering and Plastics Engineering. We are seeking new faculty to participate in the formation of the nucleus of this new graduate program. Applications are sought from investigators with established research programs and expertise in new and emerging areas. Successful candidates will be expected to participate in both the advanced materials research effort and the development of the graduate degree programs. These appointments will be to tenure track positions, with academic rank commensurate with experience. Specifically, the Department of Physics and Applied Physics is seeking individuals with a demonstrated record of accomplishment in photonics and optoelectronics materials development, characterization, and device design. Specific areas of interest include integrated photonic and optoelectronic devices, surface emitting semiconductor laser diodes and laser arrays, and visible/infrared sources and detectors. An interest in the interaction of ion beams with photonic materials is also desirable. Candidates who are selected will seek external support for and work closely with the University's new MBE-based photonic and optoelectronic device research laboratory. A doctoral degree in Physics or a related field is required. Candidates should submit a curriculum vitae, statement of research interests, reprints of significant publications and names of three references to: Dr. James J. Egan, Department Chair, Department of Physics and Applied Physics, University of Massachusetts Lowell, One University Avenue, Lowell, MA 01854. Candidates are encouraged to submit promptly, but applications will be accepted until the positions are filled. The number of positions is contingent on funding. The University of Massachusetts Lowell is an equal opportunity/affirmative action, Title IX, H/V, ADA 1990 employer.

Electronics and Telecommunications Research Institute (ETRI) is inviting creative and active candidates for Regular, Post-doctoral, and Sabbatical Leave research positions at the senior R&D level. Ph.D.s are preferred in the regular positions although experienced M.S.s and B.S.s are also considered. For the post-doctoral positions of 1-2 year contract in duration, applicants must have a Ph.D. degree earned within 5 yrs. For the Sabbatical Leave research position, applicants must be an expert or above the rank of assistant prof. on sab. leave. All areas are open with primary needs in 1) Telecommunications (communications protocol, optical communications, digital switching, satellite communications, digital system design, image & signal processing, multimedia processing, mobile communications, photonics, system control, voice coding, microwave/antenna, computer networks, intelligent networks, information security), 2) Computer (distributed processing, data base, processor design, computer architecture, computer communication, system S/W, multimedia/natural language processing, information network, computer H/W design), 3) Semiconductor (materials, process devices & design in VLSI DSP and compound semiconductor <MMIC design; MESFET, HBT, HEMT devices; DFB-LD, optical package; microwave/ optical package; MOCVD Epi growing>), and 4) Industrial/Systems Engineering. Scientists to do research on 5) Basic and Advanced Technology in the area of physical/ chemical/ mathematical/ computational/communication/information/material/biological/earth/space/cognitive sciences are also welcome. Salary is commensurate with qualifications and experiences. ETRI, founded and supported by the Government, undertakes national R&D in advanced information technology. It aspires to become one of the world's leading R&D institutions by 2000. Applicants should send a resume stating past and future R&D interests and a reference to: Director, Human Resources Development Dept., ETRI, 161 Kajong-dong, Yusong-gu, Taejon 305-350, Republic of Korea.

Research Engineer: The Astronomy Dept. of the Univ. of Illinois at Urbana-Champaign is seeking a specialist proficient in high-speed digital electronics to design, construct, program, and operate parallel computer systems (1-2 GFLOPS) and interfaces for a laser-guided adaptive optics telescope. The full-time engineer will work closely with faculty, research staff, and students in the lab at Illinois and at field sites in California. Bach. degree in EE/Physics with 3-5 years experience in high-speed digital electronics/DSPs required, or advanced degree in EE or related field. $38,000-47,000/yr, negotiable. Send resume with names/addresses of 2 references to Dr. Laird Thompson, Astronomy Dept, Univ. of IL, 1002 W. Green St., Urbana IL 61801, (217) 244-1077. To insure full consideration, applications must be received by 15 Oct 94. Proposed start date is 01 Nov 94 or ASAP. AA/EOE.

Two Tenure-Track Assistant Professorships, Department of Electrical Engineering: The University of British Columbia, The Department of Electrical Engineering, The University of British Columbia, invites applications for two tenure-track Assistant Professor appointments. One position is in electric power engineering; the other is an area which supports electric power, including electromagnetics, power electronics, systems control, knowledge-based systems or computer applications in power. A Ph.D. is required. Industrial and/or teaching experience is desirable. The successful applicant will be expected to pursue research vigorously, and to teach effectively at the graduate and undergraduate levels. Departmental facilities are extensive and include approximately 200 networked workstations and microcomputers, as well as laboratories for research in power electronics, high voltage engineering, electric machines, optoelectronics, and signal processing. Both appointments are associated with a new NSERC/British Columbia Hydro Industrial Research Chair in Advanced Techniques for Electric Power Systems Analysis, Simulation and Control. Successful applicants will be expected to collaborate with the Chair, and with British Columbia Hydro. Salary is commensurate with qualifications and experience. Start-up funding is available for purchase of equipment and support of graduate student research assistants. The position is available from January 1, 1995. Priority will be given to applications received on or before October 31, 1994. To apply, send a curriculum vitae, reprints of published papers, names of at least three references, and a statement of eligibility for employment in Canada to: Dr. R. W. Donaldson, Head, Department of Electrical Engineering, The University of British Columbia, 2356 Main Mall, Vancouver, B.C. Canada V6T 1Z4. The University of British Columbia welcomes all qualified applicants, especially women, aboriginal people, visible minorities, and persons with disabilities. In accordance with Canadian immigration requirements, priority will be given to Canadian citizens and permanent residents of Canada.

Government/Industry Positions Open

Institute for Defense Analyses, Supercomputing Research Center: Applications are invited from Ph.D. level mathematicians, statisticians, computer scientists, and electrical engineers for research positions on our technical staff. Initial appointment would be for one or two years, possibly leading to a permanent position. Wide interests, and the ability to motivate one's own work are more important than knowledge of specific technical areas. Additionally, we also organize each year a summer program for which places are available in 1995. Salaries will be competitive and commensurate with experience and qualification. IDA/SRC is an equal opportunity/affirmative action employer, and encourages application from women and members of minority groups. Send resume and publication list to: Dr. D.B. Heifetz, Deputy Director, IDA/SRC, 17100 Science Drive, Bowie, MD 20715-4300. U.S. citizenship required.

Staff Engineer to provide assist, in prep., filing, & prosecution of patent and trademark applics.-domestic & foreign. B.S. in Elec. Eng. req. Must have follow: oral & written fluency in Chinese; read. know. of Japanese; certif. or elig. for certif. as Patent Agent. Req. crswk in Microelectronics, Digital Sig. Process., Digital Electronics, VLSI Design & Computer Algorithm. 40 hrs/wk., $40,000/yr. Cvr. ltr. & resume to: B. Abraham, #4-075, MDES, 390 N. Robert St.-3rd Flr., St. Paul, MN 55101.

Senior Cobalt Process Engineer: Manage assigned Cobalt 60 Irradiator Engineering projects to facilitate the design, development, manufacturing, installation, maintenance of equipment and systems to meet manufacturing productivity and quality objectives. Provide technical analysis of projects to determine methods and techniques to be used to maintain or improve operating standards. Prepare progress reports. Provide mechanical, electrical and software designs. Assume technical responsibility of Cobalt 60

Irradiator complex to ensure the operational readiness, optimal performance and cost effective function of manufacturing equipment. Must have BS in Electrical Engineering and a minimum 4 years experience in handling Cobalt 60 Nuclear Material. In lieu of experience in job, employer will accept 4 years in radiation controls and instrumentation engineering. Either of these requirements include 4 years radiation protection and safety systems design and installation experience. Salary $46,100 - 81,100 annually. Apply at the Texas Employment Commission, San Angelo, Texas, or send resume to the Texas Employment Commission, TEC Building, Austin, Texas 78778, J.O. #TX7214032. Ad Paid by An Equal Opportunity Employer.

Engineer, Software: Evaluate, design, program, & modify LAN mgmt programs; design & implement network mgmt algorithms; identify & solve hardware/software interaction problems. Ph.D. in Comp Sci, Comp Eng, or EE reqd. Knowledge of UNIX & DOS; C, C++, Assembly; Token Ring, SNMP, B-ISDN, ATM, wireless LANs; computer network algorithms; MS Windows & X-Windows; HP 64700 & Intel 121CE emulators. $4250.00/mo. 40hr/wk. Job site/intvw: Santa Clara, CA. Send resume and ad to Job# EJ34249, P.O. Box 269065, Sacramento, CA 95826-9065.

Translators, Japanese: Electronics and computer scientists (all subspecialties) with excellent knowledge of Japanese and ability to write idiomatic English needed as freelance translators of foremost Japanese electronics research journals. Good compensation. Work in your free time. Scripta Technica, Inc., 8555 16th Street, Suite 220, Silver Spring, MD 20910, Fax: 301-588-5278.

In Camas, WA: Qualified applicant must possess MSEE Electrical Engineering with emphasis in microwave circuit theory, C language programming and three (3) years industrial experience must be in circuit design above 900 MHz for radio receivers in mobile consumer electronic products, nonlinear MMIC circuit design and foundry run using gallium arsenide, microwave/rf device modeling and parameter extraction above 900 MHz. Applicant will be responsible for all aspects of radio design for 930 MHz pager and other wireless mobile consumer radio products operating above 900 MHz. Duties will include: radio architecture planning, design and evaluation; discrete and MMIC circuit design above 900 MHz including LNAs, mixers and oscillators; extensive RF modeling and simulation using RF CAD tools; design of very low profile antennas above 900 MHz and integration of radio design into low profile packaging for mass production; debugging radio circuits using RF test equipment; C programming for GPIB based measurements. Applicant will make technical presentations of different radio architectures and RF circuit designs, and supervise/train technicians to assist in radio circuit board assembly and testing. Cover letter/resume must reflect all requirements. 40 hours per week. Salary: $56,000 per year. Mail resume by October 1, 1994: Employment Security Department, E.S. Division, Olympia, WA 98507. Job No. 438361.

Software Engineer needed to analyze business needs & convert data to programmable form for electronic processing; ascertain specific output requirements; evaluate effectiveness of existing data handling systems and develop new multi-user and multi-platform secure systems to improve production/work flow as required; specify in detail logical and/or mathematical operations to be performed by various equipment units or comprehensive computer programs; write networked client/server systems; prepare technical reports for complete operational systems; develop, troubleshoot and test prototype systems. Requires: Bachelor's Degree in Computer Science; and 1 year software engineering experience with work in network-based client/server systems, including database design & optimization; portable network system development; hardware troubleshooting; SQL query language; and NT integrated security and Microsoft Window's programming using Visual Basic, C++, Mail API, Access and Foxpro. Resume/cover letter must reflect all requirements. Salary: $50,000/year; 40 hours/week in Bellevue, WA. Send resume by October 1st, 1994 to: Job Order #438855, Employment Security Dept., E & T Div., P.O. Box 9046, Olympia, WA 98507-9046.

Communications Engineer (Microwave Sup'vsr): Design setup of fiberoptics/cable for TV; des'n/amplify most applicable syst. (in varied U.S. cities). Use maps, personal review of sites, assessmt. Test/align CATV amplifiers in field & on bench, direct technicians re: relocation, install'g, repair, maintenance of microwv transmtrs/receivers. Will do extensive travel to sites. Req. B.S. Commun. Enginr or BSEE w/major in Communc., 3 yr exp or 3 yr related exp. Sal: $600/wk. Send ad/resume to Utah Dept. Employment Security, Job Order 3016353, Att: P. Redington, E.S. Staff Services, 5th Fl., 140 E. 300 South, SLC, UT 84111.

Engineer, Sr. Design: Resp. for custom digital & analog CMOS transistor-level circuit design; CMOS circuit modeling & analysis; CMOS tech. review & prediction; & CMOS cell library devel. incl. circuit design (custom I/O driver & CMOS PLL circuits & logic gates); layout & verif.; & monitoring of wafer fab process technology devel. Reqs. MS-EE plus 3 yrs. exp. in job offered or in Electronic Design (CMOS) or Ph.D. with doct. rsrch concen. in CMOS circuit design in lieu of industrial exp. Also reqs. knowl. of & exp. (or doct. rsrch backgr.) in: CMOS device operation, device physics & modeling, incl. SPICE model & SPICE model parameter extraction devel. & verif.; transistor-level circuit design of digital & analog CMOS circuits incl. op-amps & reference circuits; & underst. of CMOS device fabrication & processing. Salary: $58,000/yr. Job site: Tempe, AZ. Qualif. applicants send resume or application letter with ad to: AZ DES Job Service, Attn: 732A, Re: 0139723, P.O. Box 6123, Phoenix, AZ 85005. Job location: Tempe. Emp. pd. ad. Proof of authorization to work in U.S. required if hired.

Software Engineer Consultant for consultant in NE Ohio. Duties: Software design and development applied to medical instrumentation for Biomedical Engineering projects and for use in industrial test and measurement instrumentation. Graphical User Interface design in Microsoft Windows environment; control of instrumentation, medical and industrial, through interface protocols; processing and display of physiological signals; real-time embedded system coding on Motorola based systems for data acquisition and recording. System test software development. Programming using C/C++, Microsoft Windows Software Development Kit, Visual Basic and Motorola Assembly language. The candidate will interact and communicate with clients, before, during and after the systems are completed to ascertain that the users needs are met. Requires: MS in Biomedical Engineering and one yr. exp. in job offered or one yr. exp. as Software Engineer; at least one yr. programming exp. in Microsoft Windows which may be concurrently acquired in job described or while working in related occupation as software engineer; coursework in Biomedical Engineering and Medical Instrumentation. Graduate academic program must have included one course in each of the following subject areas: Biomedical instrumentation; microprocessor interfacing; UNIX system programming. Must have ability to develop software for biomedical engineering systems, as evidenced by scientific publication/s, employer testimonials, academic transcripts, or letters of reference from academic advisor/s and/or professor/s who supervised research thesis work. Salary: $44,096/yr; Overtime $21.20/hr; 40 hrs/wk. 8am-5pm Mon-Fri. Must have proof of legal authority to work indefinitely in U.S. Send resume in duplicate (no calls) to J. Davies, JOB #00412, Ohio Bureau of Employment Services, PO Box 1618, Columbus, OH 43216.

Design Engineer: Researches, develops, implements and reviews system design, performs engineering analysis, reviews test results. Designs and tests digital systems, solid state electronics and radio frequency communications. Supervises projects and prepares engineering studies and field inspections. Integrates hardware, software, and firmware to form a stand alone system and uses Unix based systems. Designs fiber optic system infra structures. 40 hours per week. 8:30 a.m. to 5:00 p.m. $34,390 per year. Bachelor of Science Degree in Electrical Engineering. One year of experience or one year Design Engineer II. Must be a licensed professional engineer or licensed engineer intern. Job located in Chicago. Must have proof of legal authority to work permanently in the U.S. Please send all resumes to Illinois Department of Employment Security, 401 S. State Street, 3-South, Chicago, Illinois 60605. Reference #V-IL-11701-G. No calls. An Employer Paid Ad. Send 2 copies of resume.

Programmer Analyst to research, design & develop computer hardware & software systems for automatic detection & recovery of energy loss in transmission line & in power control systems using highly specialized switching equipment, applying principles & techniques of computer science, engineering & mathematical analysis; analyze hardware & software requirements to determine feasibility of design within time & cost constraints; consult with other engineering staff to evaluate interface between hardware & software & operational & performance requirements of overall system; formulate & design hardware & software system using scientific analysis & mathematical models to predict & measure outcome & consequences of design; oversee software system testing procedures, programming & documentation; consult with customer concerning maintenance of hardware & software systems & coordinating installation of hardware & software systems; Reqs: Bach. in Computer, Electronic or Electrical Engg., 2 yrs. exp. in job offered or 2 yrs. related exp. as Assist. Engineer or Assist. Executive. Related exp. must include detecting theft of energy & violations as well as well as energy loss. Must have 1 univ. course each in: Electric Machine Design, Mechanic or Induced Stresses in Electrical Systems, Power System Analysis, Electrical Measurements, & Control Systems; $40,000/yr, 40 hrs/wk 8a-5p. Send resume to 7310 Woodward Ave., Rm. 415, Detroit, MI 48202. Ref. #83394 "Employer Paid Ad"

Manufacturing Engineer to design resistance welding controls for electrical and mechanical welding controls; draft part description standards/maintenance; oversee accounting for materials purchases for resistance welding controls; provide advice to production personnel on layout and wiring techniques; and review quotations for parts in welding controls; documentation control of billing of creation/maintenance using Qantel MRP System; design CAD drawings of sheetmetal fabrications, sales/conceptual drawings and wiring schematics; and verify resistance weld control specifications and project coordination. Requires two years of college in Electronics Engineering Technology and five years experience in the job offered of five years experience as an Electrical Draftsman and that experience must include sheet metal fabrication, wiring/schematics, and sales/conceptual CAD drawings and design of resistance weld controls; 40 hours per week; 8:00 a.m. to 5:00 p.m.; $34,510.00 per year. Send resumes to 7310 Woodward Avenue, Room 415, Detroit, Michigan 48202. Reference No. 71294. "Employer Paid Ad."

Project Engineer: Electronics - Will provide technical expertise and original design input towards electronic devices involving analog/digital circuitry. Oversee application and use of micro-processor control, monitor circuits using embedded software and control algorithms. Education to include B.S.E.E. or B.S.C.S. with emphasis on industrial control or embedded micro-processor circuitry. A minimum of 5-7 years experience with industrial control circuitry design and major project management. Must have very good communication skills, written and verbal, as well as be outgoing, assertive and a team player. Send resume to: Zenith Controls, Inc., 830 W. 40th St., Chicago, IL 60609, Attn: Eng.

Electrical Engineer: In this position, you will be responsible for the design, documentation, implementation and support of electrical and electronic circuits and systems. This includes introducing new designs as well as diagnosing and modifying existing hardware in microprocessor-based circuit boards; motors, encoders, and servo amplifiers; analog designs including ADC's, DAC's, amplifiers; and more. Responsibilities include defining task objectives and priorities, research and diagnosis, circuit and system design

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Job Opportunity: Engineering Assistant - Hospital seeks qualified individual to: provide engineering support to electrical maintenance program; develop and implement energy conservation measures, track energy costs, apply for energy grants; develop Continuing Education programs on various engineering and maintenance subjects for Engineering and Technical staff; review governmental and accrediting body requirements; develop policies, procedures, and programs to ensure compliance; refine computerized maintenance management systems; participate in developing and monitoring budgets, construction drawing organizing, and other general office work; perform pre-purchase evaluations of equipment and manage minor remodeling projects. Must possess MSE in Electrical Engineering and at least 1 yr. exp. as an Engineering Assistant or 2 yrs. exp. as an Electrical Technician. Knowledge of computer assembly and "C" languages as demonstrated by at least 1 yr. exp. with computer systems operation is required. Minimum 40 hrs. per wk. at an annual salary of $39,270.00. Must have proof of legal authority to work permanently in the U.S. Send two (2) resumes to: Illinois Department of Employment Security, 401 S. State St. - 3 South, Chicago, Illinois 60605, Attention: Gordon Doliber. Reference # V-IL 11394-G. No calls. An Employer Paid Ad.

Research Scientist - Princeton Gamma-Tech., Inc.: Position available for developmental processing of high-purity germanium crystals. Experience in processing germanium, vacuum and cryogenic technology and semiconductor physics preferred. Minimum 24 month assignment with full benefits. Could develop into permanent position. PGT is an EOE. Candidates please send curriculum vitae to L. Wyckoff, PGT, 1200 State Road, Princeton, NJ 08540.

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ENABLING THE DISABLED. Computing power these days can frequently serve as a useful surrogate for human senses, according to this pair of articles. Mainly in the United States and Europe, researchers are employing it to create tools for the disabled. Examples include robotic assists for the paralyzed and devices that bestow synthetic speech on those who are voiceless. The infirm elderly, whose numbers in the West are rapidly growing, are among the beneficiaries.

DEFENSE ACQUISITION UNDER FIRE. If the United States is to hang onto high-tech military might despite a reduced budget, the Department of Defense must transform its acquisition system. According to an engineer with many years of experience in military electronics, everyone involved—from the three armed services to the individual contractors—needs to mend their ways. He says in addition that many laws and many layers of regulations must be revised.

HUNTING THE BOSON. After the demise of a too ambitious U.S. project, hopes for further light on the nature of matter are now pinned to the Large Hadron Collider. To be constructed at a cost of US $3 billion near Geneva, on a site straddling the boundary between Switzerland and France, the supercollider will consolidate Europe's preeminence in particle physics and push the state of the art in magnetics, cryogenics, and data discrimination—that is, if it can be built at all.

THE POWER OF SUNLIGHT. Photovoltaics programs backed by the European Union are supplying electric power for lighting, pumping water, and the refrigeration of medicine in rural West Africa. In India, meanwhile, a photovoltaics industry has been under way for some years now.

This set of articles is the first in a series of features on technologies appropriate for use by developing nations. Also covered is what those technologies need in the way of changed policies, better financing, and system improvements.

PROFILE OF A MEDALIST. The man who won the IEEE's top award this year—its Medal of Honor—is interviewed by a *Spectrum* editor. Born in Beijing, brought up in Hong Kong, and educated at a U.S. university, Alfred Y. Cho tells readers of his career in research and how he arrived at his present eminence as director of the semiconductor research laboratory at AT&T Bell Laboratories in Murray Hill, N.J.

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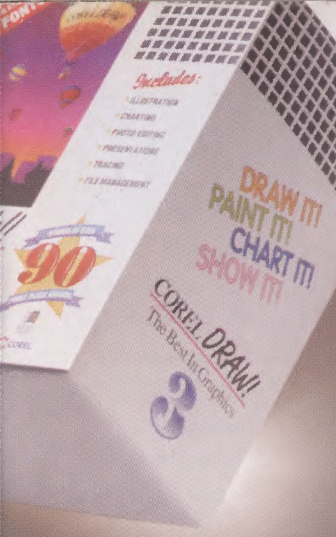

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